SOME OCCUPATIONAL AND ECOTOXICOLOGICAL HAZARDS ASSOCIATED WITH SELECTED INDUSTRIES IN SOUTH-EASTERN NIGERIA.

BY

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Certification

This is to certify that this work "Some Occupational and Ecotoxicological Hazards associated with selected industries in South-Eastern Nigeria" was carried out by I, Carol Chioma Obinwanne (Registration Number: 20114775498) in partial fulfilment for the award of the degree of (Ph.D in Environmental Health Biology in the Department of Biotechnology) of the Federal University of Technology, Owerri.

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Dedication

This work is dedicated to my son, Uchechukwu Obinwanne, an undergraduate of Electronic Engineering at the Voronezh State University of Engineering Technology, Russia, under Federal government scholarship (BEA).

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Abstract

This study was focused on ascertaining some occupational and ecotoxicological hazards associated with healthcare, quarrying, road construction, asphalt and brewery industries in South-Eastern Nigeria. The sample population comprised one hundred and thirty-five female and male workers within the ages of twenty-one and sixty years who had been on the job for three or more years. For the control group, fifteen human subjects who were non-industrial workers within the same age bracket were used. Health status of workers was assessed using chest x-ray, specimens of sputum, full blood count, erythrocyte sedimentation rate (ESR) and hair washings. Air quality was assessed with CROWCON Gasman II monitor/analyser while Atomic Absorption Spectroscopy was used to identify heavy metals in hair, water, soil and leaf samples. Physicochemical and microbiological properties of water and soil with heavy metal accumulation and proximate analysis of plants, in and around work environment were determined using standard methods. Results obtained from the health status of workers showed that 16% of males and 13% of females sampled had a high incidence of consolidation of the lung as well as peak values of the cardiothoracic ratio (0.45±0.06 cm) and (0.40±0.08 cm) respectively, in road construction industries. Sputum for *Mycobacterium tuberculosis* tested positive in 5% of the males in the asphalt industry. Lymphocytosis among males; eosinophilia and high ESR among females, were significantly different ($p<0.05$) from their controls in five (5) industries. Peak values of lead (0.26±0.04 mg/l) and cadmium (0.79±0.03 mg/l) from hair washing were recorded among quarry and healthcare workers, respectively. In air quality results, sulphur (IV) oxide was significantly different ($p<0.05$) from their controls in the five industries. Asphalt industry was recorded to be the worst, with a pollution level of 92.35±3.49 $\mu g/m^3$ for particulate matter ($\mu g/m^3$), while the brewery industry had the least with a pollution concentration level of 5.19±3.09 $\mu g/m^3$. Physicochemical and microbial analyses of freshwater and soil, showed that Nworie river near healthcare industries had a dominance of pH (8.07±2.11); total dissolved solids (TDS), biochemical oxygen demand, nitrate, nitrate-nitrogen, phosphate, phosphorous, lead, cadmium and chromium, but had least values ($2.9x10^5$±3.0 CFU/ml) of total bacteria. Akpoha river near quarry had peak values of temperature (33.20±1.97°C); conductivity (6262.67±10503.89 µS/cm) mercury, total fungal count and total hydrocarbon utilizing fungi (HUF). The river Akpou-ga Nike near asphalt industry had peak values of total bacterial count ($7.3x10^5$±$8.1x10^5$ CFU/ml) and the least values ($2.0x10^3$±2.6 CFU/ml) of total fungal count. Njaba river near the brewery, had the peak values of dissolved oxygen, arsenic and total petroleum utilizing heterotrophic bacteria but recorded least values of temperature, pH, conductivity, TDS, lead, cadmium, mercury and chromium. For soil, the industries: healthcare, road construction and brewery had loamy sand soils, while quarry and asphalt had sandy soils. The peak values (7.45±0.01) of pH was recorded in samples from the brewery and least values (1.96±0.02) from asphalt industries. Soil mean values of pH, lead, cadmium, chromium, total bacterial count and total hydrocarbon utilizing fungi, were significantly different ($p<0.05$) from their controls in five industries. The peak values of soil total bacterial count ($6.2x10^6$±$1.0x10^5$ CFU/g) was recorded in the healthcare industry. There was no growth of hydrocarbon utilizing bacterial (HUB) and fungi, in quarry and asphalt industries. In the determination of the presence of heavy metals and proximate analysis of plants, it was discovered that the mean values of lead, in the leaves of *Manihot esculenta and Carica papaya*, were significantly different ($p<0.05$) from their controls in the industries studied, as well as the mean values of macronutrients, in healthcare, asphalt and brewery industries. There were significant occupational and ecotoxicological hazards associated with industries studied, such as pneumonitis; and possible inflammatory biomarkers: lymphocytosis among males; eosinophilia with high ESR values among the female workers; Alopecia areata (with "i hair" as a potential biomarker), in the brewery industry and air pollutant, $TSPM_{10}$ $\mu g/m^3$. There was a significant effect of poor air quality around the work area, such as Status Asthmaticus and sulphur (IV) oxide pollution. Industrial toxicants had significant effects on the physicochemical and microbial properties of water and soil around the workplace, and adjoining environments such as the predominance of lead and total bacterial count. The workplace was indeed contaminated and had adverse health effects on both workers and the environment.

KEYWORDS: Occupational, Ecotoxicological, Hazards, Hydrocarbon Utilizing Bacterial (HUB), Quarrying.

Chapter I: Introduction

1.1 Background Information

The proliferation of industries in South-Eastern Nigeria has resulted in various occupational and ecotoxicological hazards. These hazards include threats to biodiversity, health hazards to residents, archaeological properties, social and cultural values. The ecosystem has the highest concentrations of biodiversity that ever existed with arable terrain that can significantly improve the productivity of crops, economic trees, and aquatic organisms. This well-endowed ecosystem is experiencing losses from industrial pollution which resulted in extensive damage of its terrain that in the next thirty years with the continuous contamination of air, water and soil, there will be massive destruction of the ecosystem (Klieman, 2012). Pollutants generated in industries are usually dared to be one of the prime factors contributing to air, water and soil pollution. Globally, pollution is the most frequent cause of disease and premature death. An estimated 9 million premature deaths occurred in 2015; 16% of all deaths worldwide (Landrigan, 2018).

The naturally occurring heavy metals in the earth include lead (Pb), cadmium (Cd), manganese (Mn), and metalloids such as arsenic (As). However, with increasing human activities, especially mining and industrial processes, these metals Pb, Cd and As becomes increasingly exposed and are hazardous (Yu, Tingping, Mengtong, Jieyi & Ruixue, 2017). Heavy metal contamination of the soil and its toxicity, is quite challenging. It has wide distribution, persistence, and can be a contaminant to plants and can lead to various diseases (Qiao, 2011; Huang-Bian, 2016; Huang-Wang, 2016; Huang-Dai, 2015). Industrial and manufacturing activities, cause about 50% of all pollution resulting to severe consequences (Liu, 2017) which include global warming from the steady rise of industrial activities and release of greenhouse gases including carbon (IV) oxide (CO_2) (Gant, 2017) and methane

(CH_4) into the atmosphere. The thermal radiation from the sun, absorbed by greenhouse gases, threatens human survival (Code of Practice and Guidance, 2013). It is clear that, by the end of the twenty-first century, global temperatures will rise by an additional 5.8 degrees Fahrenheit (Gaoa, 2017) also there will be an increase in sea levels (the United States Environmental Protection Agency, 2016). Water bodies get polluted when industrial effluents containing various contaminants like dangerous chemicals (Garcia, 2017) radioactive materials, heavy metals (Hall, 2017) gets discharged into it. Also, organic sludge produced during the treatment of industrial effluents as a byproduct contains harmful and persistent organic compounds which adversely affects humans, aquatic organisms and the environments. Increase in the industrial discharge of gases increases the atmospheric concentration to the extent of formation of acid rains and predisposing workers to various airway diseases (Crook, 2017).

When toxic materials and chemicals get to landfills, they accumulates in the topsoil thereby, depreciating the fertility and biological activity of the soil which results to ecological imbalances thus creating problems in crop productivity harming human health. The World Health Organization (WHO, 2018) revealed that in 2012, the 3 million deaths worldwide, was as a result of ambient air pollution, also, it was responsible for 169,250 child deaths under five. Disasters have resulted from industrial activities that led to the end of over 8,000 people in Bhopal, India in 1984, and the adverse effects persisted more than two decades after the incidence (Eckerman, 2013). Natural habitats destroyed by mining, deforestation, and utilisation of water resources for industrial production, exposed the organisms to predators and extreme living conditions leading to the extinction of some of the wildlife species (Staff, 2010). The explosion that led to the accidental discharge of BP oil (Chang, 2014) which resulted to the death of eleven on the rig and injury to seventeen workers; claimed lives of thousands of aquatic organisms leading to the extinction of rare species.

Recent research in the healthcare industry reported that pharmaceutical wastes from human and farm animal consumption are causing harm in the ecosystem of rivers around the world (Bregoli, 2018). New biological risks arise, for instance, in the biotechnology industry, where workers who are deeply engaged in the production can be at particular risk of airborne contaminants. Airborne dust is of particular concern because they are well known to be associated with occupational lung diseases such as pneumonitis (Barber, 2017) as well as lead poisoning, at higher levels of exposure. Other dust-related disorders, such as cancer, asthma, and allergic alveolitis, may occur at much lower exposure levels (WHO, 2002). Workers were dying young from occupational hazards and were confused as part of the job. The physicians at the early period were uneducated on the relationship between work and health, so industrial related diseases were confused with other causes (Balmforth, 2015). An occupational hazard is an impending danger to a worker from a substance or situation, even though often foreseeable in the workplace (Ministry of Labour, Training and Skills Development, 2016). Ecotoxicology is a mix of ecology, toxicology, analytical chemistry, molecular biology, mathematics and physiological impacts of contaminants on individuals, populations, natural communities, and ecosystems (Gonzalez & Pierron, 2015).

Hazards in the healthcare industry involve both patients and healthy individuals. The patients are treated for various ailments, while healthy individuals may suffer from nosocomial infections. Needle-stick injury remains common (Ofili, Asuzu, & Okojie, 2004) danger which expose healthcare workers to the risk of blood-borne diseases, which include serum hepatitis and human immunodeficiency virus (HIV). When Pharmaceutical products discharged into the environment, it is either in the form of its original state or in a way that still has properties to show its innovative compound. The treatment plants that carries wastewater from Pharmaceutical industries was not designed to isolate and safely discharge its content. Consequently, various forms of this mixture of compound were discharged unto the environment.

More so, the use of sewage sludge as fertiliser and the release of treated wastewater into rivers has resulted in various degrees of contamination of the environment (Peake, Braund, Tong & Tremblay, 2016). Low concentrations of pharmaceuticals in wastewater can have adverse impacts on the physiology and behaviour of a variety of organisms as it contains a highly active compound that targets specific biologic systems. The antibiotic composition of wastewater makes it available to micro-organisms even on to the point of discharge of the wastewater after treatment into aquatic environment processes leading to the development of antibiotic resistance (Rizzo, 2013; WHO, 2014)

Quarrying industry exposes workers to airborne particulate hazards, free crystalline silica (Eranna, 2014) in the overburden of the ceiling, floor or ore deposit of an underground mine. Silicosis is typical pneumoconiosis that develops insidiously after years of exposure to silica. There is an increased risk of tuberculosis, lung cancer (the United States Environmental Protection Agency, 2005a), rheumatoid arthritis, and death. Besides, noise is a significant problem in quarrying (Gyamfi, Amankwaa, Sekyere, & Boateng, 2016) as sound level can exceed 120 dB(A), and the alternative method of cutting stone was with very high-pressure water (Henriques, 2004), with operating pressure: 2000 bar (30,000 psi) and sound level 108.0 – 114.8dB(A) (Hutt, 2004; NIOSH, 2015). The sound level exceeded the second action level as was stipulated in the Noise at Work Regulation (1989). Quarrying has resulted in the various negative impacts in the environment, and one of such colossal damage involves threat to biodiversity which refers to different species of living organisms including reptiles, birds, mammals, fish, insects, invertebrates, plants, fungi and micro-organisms. The conservation of biodiversity is of essence as to all species are interlinked within nature and this delicate balance that exists enhance survival in the environment (Anand, 2006).

The road construction industry hazards include Merging - when lanes are blocked, drivers may be required to merge into fewer lanes without much notice, which results in heavy traffic that can give rise to emergencies. In construction sites, barricades, and walls provide little room for driver misjudge, which can predispose commuters to a road traffic accident (Beers, 2018). Debris - The roadways contaminated with pieces of debris from construction waste product expose passengers to danger (Müller & Saathoff, 2015). Heavy metals (especially lead), salts, organic molecules, ozone, and polycyclic aromatic hydrocarbons (PAHs), which are combustion byproducts of gasoline and fossil fuels get to roadside environments, changes soil density, temperature, soil water content, light levels, dust, surface waters, patterns of runoff, and sedimentation (Allen-Burton, 2001). Roads promote landscape modifications, the dispersal of exotic species by altering habitats, stressing native species, and providing movement corridors, increased hunting, fishing, passive harassment of animals, and landscape modifications (Bennett, 2003).

Hazards also emanate from the asphalt industry. Asphalt is made up of complex chemicals and the Recommended Exposure Limit (REL) of 5 mg/m^3 over 15 minutes, determined by the National Institute for Occupational Safety and Health (NIOSH, 2015). Workers are more at risk when the asphalt is heated up to 199°C (390°F) for pavement (Cavallari, 2012). Asphalt fumes result in various allergic situation ranging from itching of the eyes, the nose, throat, giving rise to cough, gasping respiration and breathlessness. The asphalt emissions are known to be carcinogenic (NIOSH, 2014; IARC, 2015; ACGIH, 2015). The skin may sustain varying degrees of burns resulting in inflammation and infective lesion. Long-term contact can cause skin pigment change, which is made worse by sunlight exposure. Cutback and Rapid Curing Asphalt are flammable. Asphalt, oxidised is a carcinogen (Environment and Climate Change Canada, 2017).

The brewing industry is associated with CO_2, a byproduct of the fermentation process, an odourless and colourless gas, heavier than air, and collects at the bottom of containers. The gas displaces oxygen (O_2), leading to rapid asphyxiation, or present as a toxin in its own right. Exposure to as little as 0.5% volume CO_2 represents a toxic health hazard, while concentrations higher than 10% volume can lead to death (Wark, 1998). Carbon IV oxide can spill out of fermenting tanks and sink to the brewery floor, where it forms deadly, invisible pockets. The production and discharge of CO_2 could cause depletion of ozone, global warming, and health effects to humans (SMEWorld, 2012). The breweries solid waste and byproducts, energy use, water consumption, and wastewater are also significant environmental issues (Weinberg, 2014). Vessels used in the brewery are under high pressure with the problems of flammability (Ivings, 2016) and create a very toxic environment.

There was an increased death rate in the early 1900 and prevalence of the pulmonary disease in hospitals were evident in the occupational history of patients that worked in industries with marked dusty operations (Madl *et al.* 2008). Researchers then took an interest in professional cohort studies which served as the basis for the first occupational exposure limits in the 1930s. Studies in foundries done earlier revealed that abrasive blasting operations were hazardous, and that led to the base for various engineering review and Personal Protective Equipment that were still in place till date (Madl *et al.* 2008). Occupational Health in Nigeria started with the employment of General Practitioner in few organisations such as the United African Company and John Holt (Adeniran, 2016). The Nigerian government in 1969, requested from the International Labour Organisation (ILO) and obtained technical assistance on the development of occupational health. International Occupational Health was the oldest international body in modern times, which was affiliated to ILO and was concerned with global health and safety of people at work (Adeniran, 2016).

Landmark legislation in occupational health in Nigeria was the Factories decree enacted in 1987. This decree with significant revision of the colonial law, Factories Act 1958, changed the definition of the factory from an enterprise with a workforce of ten or more to the assumption of one or more workers, which provided inadvertence for the various small-scale enterprises that engage the majority of the workforce in Nigeria. The Factories Act 1990 was the current legislation. The Factory Inspectorate of the Ministry of Labour put in place a National Policy on Safety and Health in 2006 which details the responsibilities of industrial workers and government agencies in the maintenance of the occupational health and safety of workers (Omokhodion, 2009). There was, a lack of research assessing occupational hazards in the areas of this study, resulting in ecosystem changes and profound transformations. However, the research on Biochemical indicators of occupational health hazards in Nkalagu cement industry workers, Nigeria by Ezeonu & Ezejiofor (1999) highlighted the implications of environmental risks to occupational health.

There was a gap of knowledge, in understanding the relationship between occupational and ecotoxicological hazards, how adverse effects occur, and how pathways of various diseases can be bridged through sustainable utilisation of safe work ethics and ecosystem protection. South-Eastern Nigeria is made up of Abia, Anambra, Ebonyi, Enugu and Imo States (Uchem, 2001) with a population of about twenty-one million, six hundred and thirty thousand, two hundred and seventy-one (National Population Commission, 2006). The projected population in 2018 was thirty million eight hundred and three thousand six hundred and eighty-four (See Appendix 21). The number of workers exposed to some occupational hazards in five industries: healthcare, quarry, road construction, asphalt, and the brewery was two hundred and sixteen thousand three hundred and three (1%). This one per cent is a significant percentage of the total population.

1.2 Problem Statement

There is a shortage of data in occupational and ecotoxicological hazards in the areas of study. There has been an increased report of certain health challenges such as pneumonitis, as well as environmental pollution challenge, with the proliferation of industries in South-Eastern Nigeria.

1.3 Objectives

This study aimed at ascertaining some occupational and ecotoxicological hazards associated with healthcare, quarrying, road construction, asphalt and brewery industries in the South-Eastern Nigeria using these objectives:

i. To assess the health status of workers in the selected industries.

ii. To determine the air quality of the immediate and the adjoining work environment.

iii. To assess the physicochemical and microbial properties of available freshwater and soil around the work environment.

iv. To assess the heavy metal accumulation and macronutrients in possible plants in soils around the work environment

1.4 Hypothesis

Null hypothesis 1: There was no significant occupational and ecotoxicological hazards associated with healthcare, quarry, road construction, asphalt, and brewery industries.

Null hypothesis 2: There was no significant health effect of occupational and ecotoxicological hazards on workers.

Null hypothesis 3: There was no significant adverse effect of occupational and ecotoxicological hazards on air quality around the work area.

Null hypothesis 4: Industrial toxicants had no significant effects on the physicochemical properties of water and soil around the work environment and adjoining environment.

1.5 Justification of study

This study will create awareness among workers, employers, trade unions and the general public on the relationship between work, ecosystem, and health.

It will help to develop diagnostic criteria for some occupational diseases.

It will assist in early rehabilitation, maintenance well-being and functional working capacity of the workers.

1.6 Scope of study

The scope of this study was to assess the occupational health and ecotoxicological hazards in healthcare, quarry, road construction, asphalt and brewery industries, in the south eastern part of Nigeria. It includes the analysis of the following health indices: anaemia, leukocytosis, pneumonitis, tuberculosis, Status Asthmaticus, "Itai- Itai" disease cadmium poisoning, "i hair" in alopecia areata, and lead poisoning of workers. It also involved the investigation of the workers in these industries using parameters such as full blood count, erythrocyte sedimentation rate, chest radiology, sputum for *Mycobacterium tuberculosis*, heavy metal accumulation on the hair of the workers. As part of the study, the air quality of the work environment and the adjoining areas were reviewed. In addition, physicochemical and microbial properties of any water body and soil with the heavy metal accumulation and macronutrients in plants around the targeted industries were carried out.

Chapter II: Literature Review

Increase in industrial and developmental pressures in many developing parts of the world like South-Eastern Nigeria is associated with various human-made occupational and ecotoxicological hazards. This high and preventable burden of ill health faced by workers in the developing world was the result of ignorance, resulting in the workers not adhering to the guiding rules in the occupation (Adei, 2009). There was a resultant increase in occupational dust hazards in healthcare, quarrying, road construction, asphalt, and brewery industries. In the "Glossary of Atmospheric Chemistry Terms" Dust was described as a minute solid particles about 1 to 100μm in diameter which can be introduced into the air by human-made processes like milling, drilling, demolition, with sweeping or through natural processes like a volcanic eruption. Fine particles of dust get suspended in air and through gravitational force settles slowly (IUPAC, 1990). Dust particles <1 mm, that got suspended in air and sinking due to gravity was negligible. As fine dust got suspended in the air, the particle size of 1mm used the velocity of 0.03mm/sec which kept specks of dust in the air, for a considerable period before settling. There were various sizes of specks of dust between 1μm to 100μm and were airborne solid particles with specific physical properties and ambient conditions.

Mineral powder with free crystalline silica (as quartz), was the characteristic dust seen in quarrying. Metallic powder that included heavy metal, such as lead, cadmium; organic and vegetable dust, such as flour, cotton and pollen grains; biohazards, such as viable particles, moulds, and spores were hazardous. Industrial activities generated dust, some other natural processes: pollen, volcanic ashes, and sandstorms also contributed to the tremendous amount of dust in the work environment. Dust emanating from asbestos was hazardous to health because of the shape of the particle. The size of particles with diameter < 3 mm and length > 5 mm, were classified as fibres, which included asbestos, carbon, and silicon carbide. These particles gave rise to health hazards.

The gravity of workplace risks necessitated its inclusion in the recent International Labour Organization (ILO) report. The ILO Chemical Control Banding Toolkit (2003) estimated that occupational diseases and injuries contributed up to 2 million deaths per annum. The data for non-fatal illness and trauma were not available for countries, which made it impossible to know the number of workers affected. The ILO also noted that about 4 per cent drop in the GDP resulted from work-related diseases (Takala, 2002). The World Health Organization (WHO, 2002) considered the global burden of occupational diseases in its comparative risk assessment. The diseases included were, silicosis, asbestosis, coal workers' pneumoconiosis, hepatitis B, hepatitis C, and HIV/AIDS infections from contaminated sharps injuries among healthcare workers. The WHO comparative approach used a standard statistical model that allowed a reader to compare the contribution of several risk factors to a single outcome, lung cancer (WHO, 2002). The Comparative Risk Assessment Collaborating Group, (Ezzati, Lopez, Rodgers, Vander & Murray, 2002) conducted a research on 'Selected Major Risk Factors, Global and Regional Burden of Disease' and concluded that substantial proportions of global disease burden were attributable to these significant risks, and that, developing countries suffered most of the challenges.

2.1 Some occupational and ecotoxicological hazards in healthcare industries

In healthcare industries, disinfectants and pharmaceuticals were used regularly for surgical and medical treatment for patients diagnosed with various diseases. The diagnostic agents and non-metabolized medicines excreted by patients, reach the wastewater and may generate risks for aquatic organisms (Obi, Waboso, & Ozumba, 2005). In the research conducted on Ecotoxicological risk assessment of hospital wastewater: a proposed framework for raw effluents discharged into public sewer network (Emmanuela, Perrodina, Keck, Blanchard & Vermande, 2005), revealed the presence of viruses and some pathogenic bacteria. Low most probable population for faecal coliforms used as an indirect detection of antibiotics and disinfectants presence. The other contaminants excreted were non-metabolized and unused pharmaceuticals, molecules from halogenated organic compounds (organohalogen compounds) adsorbable on activated carbon and radioisotopes. These toxic waste further exposed the healthcare professionals to occupational diseases and the environment was also, threatened. Soils in the environment vary greatly in their ability to bind radioisotopes (an atom that has excess nuclear energy). The finely-grained clay soil that contained variable amounts of water trapped in the mineral structure and humic acids alter the distribution of the isotopes between the soil water and the soil. Some plants, absorbed and concentrate metals within their tissues and are known as hyperaccumulators. More so, iodine, the heaviest stable halogens, commonly used at the emergency unit, was first isolated from seaweed in France, which suggests that seaweed is an iodine hyperaccumulator (Gosse & Phillips, 2001).

WHO (1994) further revealed that healthcare workers were exposed to hazardous glutaraldehyde and ethylene oxide chemicals; physical hazards, such as noise and radiation, ergonomic (heavy lifting); psychosocial hazards, such as stress and violence, and contact with electricity that resulted to fire explosion. Furthermore, other challenges faced by healthcare workers included dangers associated with the use of hospital equipment and devices for radiotherapy. Healthcare workers in the laboratories, theatres, delivery and emergency rooms had an enhanced hazard alongside with workers that handled blood-contaminated items. The yearly exposures of healthcare workers to various blood-borne pathogens were two million to HBV, 0.9 million to HCV and 170000 to HIV (WHO, 1994). Healthcare workers had been erroneously considered "immuned" to injury or illnesses. Often healthcare givers were expected to work themselves out in taking care of the sick. The patients come first. Exposures and contamination of workers to various blood-borne diseases could be prevented through the management of vulnerabilities and implementation of universal precautions. In addition, immunisation against hepatitis B, and provision of personal protective equipment were of essence to the control of diseases. The World Health Organisation (2006), reported in: 'Working Together for Health on Human Resources' that there was an urgent call for the protection and support of the health workforce as there was an acute global shortage of health personnel. More so, that unsafe working conditions contributed to health workers attrition in many countries due to work-related illness and injury and the resultant fear of occupational infection, such as acquired immunodeficiency syndrome and Tuberculosis (WHO, 2006). Another report was on severe health workforce crisis. The need for protection of health personnel was of paramount importance as to the employment of enough trained health personnel — the WHO spearheaded the development of national programs for the health status of industrial workers. The administration of hepatitis B Statistics showed that less than 20% of health workers had received all three doses needed for immunity against the preventable diseases. The cause of 95% of the HIV occupational seroconversions was preventable and other blood-borne viruses and bacteria.

A study carried out by Obi *et al.* (2005) evaluated the level of occupational risk, and behaviour of surgeons towards HIV-infected patients concluded that preoperative screening should be carried out, and caution observed during surgery, for infected cases. More so, that infected patients should not be discriminated against in treatment, provided necessary protective materials were available. The protective material served its purpose provided needle stick injury that carries blood-borne diseases was averted. Another study carried out among Healthcare workers in hemodialysis units in Nigeria by Amira (2014) established that needle-stick and sharps injuries carried the risk of infection and occupational hazards for all healthcare professionals involved in clinical care. Hollow-bore needles were responsible for 82.9% of the Needle Stick Injuries (Obi *et al.* 2005). Many of job hazards can be averted when the practice of universal precautions were adhered to as well as workers education on such precautionary methods. The method included proper immunisation against hepatitis B, regular use of sterile gloves any time a dialysis machine and dirty dialysers were touched while aseptic techniques between patients must be maintained. Aseptic technic must also be maintained when procedure for intravenous therapy was being carried out. The administration of the medication entailed carefulness and needed a separate medication preparation area to be used.

Anjali (2006) on the research, impact of the environment on infections in healthcare facilities, established that infections gotten from the hospital were among the leading causes of death in the United States. It was killing more Americans than AIDS, breast cancer, or automobile accidents. The researcher in a literature review of peer-reviewed journal articles reported that in 1995, hospital-acquired infections contributed to more than 88,000 deaths (one death every six minutes) and cost $4.5 (Anjali, 2006). Nosocomial infections retransmitted in hospitals through three main environmental routes: air, surface contact, and water. Well ventilated hospital removes the hazard of airborne infections. Airborne infections often spread due to poor ventilation in carrying out construction or renovation work when that resulted in much circulation of dust carrying airborne pathogens. The two key aspects of maintaining good air quality were by providing clean filtered air and effectively controlling indoor air pollution through ventilation. Most nosocomial infections retransmitted through contact with the hands of nurses and physicians and poor hand washing compliance posed serious problems. The good practice of regular hand washing in alcohol-rub dispensers had tremendously reduced the spread of infections in hospitals. Single-bed rooms are easier to isolate infectious pathogens and disinfect single-bed rooms than multi-occupancy rooms (Anjali, 2006). Waterborne infections spread through direct contact (for hydrotherapy), ingestion of contaminated water, indirect contact, and inhalation of aerosols dispersed from water sources. The cleaning, maintenance, and testing of water systems and point-of-use fixtures were important for preventing the spread of waterborne infections (Anjali, 2006).

The WHO (1994) stated that occupational health encompasses all aspects of health in the workplace and focused on primary prevention of risks. Effective infection control and successful implementation of primary prevention of hazards strategies required an active committee in conducting, comprehensive review of occupational hazards regularly and ensuring compliance. The reduction in hospital-acquired infections was achieved by enhancement in the control of environmental sources of transmission of infections.

2.2 Some occupational and ecotoxicological hazards in quarry industries

The increase in the activities of quarry-mining companies in the Ishiagu area of Southeastern Nigeria resulted in health hazards (Crook, 2017) and threats to biodiversity (Achyut, Shrestha, Shree-Sen, Uprteti, & Gautam, 2009) and archeological properties (Aroh *et al.* 2010). Dust in quarrying was one of the major cause of occupational and ecotoxicological hazards (Howard & Cameron, 1998). Dust accumulated from different sources; drilling, crushing and screening (Langer, 2001), also, from excavation, haul roads and blasting. Work conditions from various quarry sites such as rock properties, moisture, ambient air quality, air currents, and winds, affected the impact of dust generated during the extraction of aggregate and dimension stone. The extent of the operation and nearness of the site to areas of human habitation also contributed to the generation of dust. However, dry or wet techniques were used to control the dust. Dry techniques involved covers on conveyors, vacuum systems, and bag-houses that evacuated dust before the stream of air was let off to the atmosphere. The wet suppression involved the use of pressurised water sprays located in areas where dust concentrated. Workers were protected from dust through the use of enclosed, air-conditioned cabs on equipment and, where necessary, the use of respirators. The report by Ude, Obinwa, Akubugwo, Ugbogu, & Ugbogu (2012) on effects of selected well water sources at Ishiagu quarry site, Ebonyi State, Nigeria on basic haematological parameters in peripheral blood of albino rats revealed abnormal haematological values. The haemoglobin concentration, haematocrit value, red blood cell count and neutrophils decreased, while platelet count increased significantly at ($p<0.05$) in test groups compared to control. These findings showed that consumption of well-water around the quarry site in Ishiagu can cause anaemia in the experimental animals and may not be safe for human consumption. Though the workers at Ishiagu quarry denied the use of nearby stream for domestic purposes.

The crushed stone industries that was sited close to human habitations were indicted to be the main cause of noise pollution (National Academy of Sciences, 1980) as blasting occurred daily, once or twice in a year. Dimension stone quarrying used significantly different techniques than that used in crushed stone operations. Huge amounts of explosives were used in crushed stone operations to produce appropriate-sized rubble, whereas lesser amounts of explosives were used to loosen large blocks of stone in the dimension stone industry. Engineering techniques, such as enclosing equipment and vacuums used in removing dust, can mitigate the impacts of noise and dust. Noise pollution from the quarrying industry increased with the amount of explosive, atmospheric conditions, and proximity of human habitation to the blast. The area behind the blast were exposed to fewer noise hazards than areas in front of the blast, as the impacts of blasting were affected by weather, geology, and topography.

Quarries can occupy a large portion of the visual landscape (Moore, 1999; National Academy of Sciences, 1980). However, the use of well-documented limits of blasting mitigated both the occupational and ecotoxicological hazards (World Health Organization, 1994). The detonation of explosives attracted the release of an enormous amount of energy. Most of the energy of a properly designed blast concentrated on the displacement of rock from the quarry site, while some passed as vibration through and within the surface of the earth and air. The displacement of rock resulted in the vibration of the earth when the detonation happened within a few meters away (Nzegbule & Ekpo, 2007). Serious hazard emanated from poorly designed blasts that resulted in rocks being projected long distances from the blast site as a fly rock. More so, blast-induced vibrations and shock waves, disengaged rock particles, stalagmites, and stalactites and led to the collapse of cave roofs and cracking of walls (Adei, 2009). The amounts of explosives used depended on the location of the industry. Those industries sited in isolated areas, away from human settlements used larger amounts of explosives that generated an enormous amount of noise. The earth-moving and processing equipment with blasting were the primary sources of noise during the extraction of aggregate and dimension stone. The ground cover of the surrounding quarrying site, the topography, and climatic conditions determined the impacts of noise (Langer, 2001). The impacts of stockpiles were constructed to form sound barriers. Noisy equipment (such as crushers) were enclosed in soundproof structures some distance away from human settlements. Noisy operations were scheduled or limited to certain times of the day. Careful routing of trucks, proper location of access roads, and good use of acceleration and deceleration lanes reduced noise pollution from the truck. Adequate use of hearing protectors, the use of enclosed and air-conditioned cabs on equipment reduced the sound level to the barest minimum before it eventually got to the workers. Regular health screening was important in the quarry industry for early detection of hazards and adequate management.

2.3 Some occupational and ecotoxicological hazards in road construction industries

The World Bank had observed that poor transport infrastructure and services in sub-Saharan Africa frustrated poverty reduction (Pleassis-Fraissard, 2007). Two-thirds of Africa's rural population, which was about 300 million of the world's poorest people, do not have access to an all-weather road. Roadside construction workers suffered the risk of being knocked down by car or truck as it passed through a work zone, and the driver unaware or ignoring flags, cones, or other warnings (Virginia Tech, 2015). The American Road & Transportation Builders

Association reported cases of fatalities in highway work-zone related incidents that took the lives of 579 people in 2013 (Virginia Tech, 2015).

In the case of South-Eastern Nigeria, the majority of their road network were constructed decades ago. Presently, roads reconstructed have been carried out with inferior materials. The small designs and lack of quality control during the building process contributed to the poor state of the road network. The study carried out by Ebuzoeme (2005) on 'Evaluating the significance of poor road design as a factor of the road failure of Onitsha-Enugu expressway, South-Eastern Nigeria concluded that poor road design was not a significant factor of the road failure. However, there was a need for redesigning and reconstruction of the roadway because poor road design increased the hazards encountered by commuters. More so, researchers Mafuyai, Kamoh, Kangpe, Ayuba & Eneji (2015) reported that road construction work on roadways exposed workers to lead.

Edgar-Geddie (2012) in a Guide to lead exposure in the road construction industry, revealed that a certain dose of lead was toxic. Lead presence in the air was inhaled as mineral dust through the upper respiratory tract into the lungs. The ingested lead entered the gastrointestinal tract, into the bloodstream through where some were channelled for excretion while some were stored. A significant portion of lead transmitted to the body through inhalation, got into the bloodstream, circulated to the various organs, and tissues where it got stored while some were excreted to the exterior. The quantity absorbed and stored increased with more exposure. Long-term (chronic) overexposure to lead with insufficient excretion from the body led to an irreversible damage to cells and organs in the body. Lead poisoning caused deleterious effect on the central nervous system, especially the brain. Long-term human exposure to lead was proven to impair the male and female reproductive systems. When conception resulted from sperm cells that were mal-formed from lead exposure, it resulted to various congenital disabilities which includ0ed: mental retardation, and behavioural disorders or death in the first year of life for children whose parents were exposed to lead.

The interim OSHA standard, published in 1993, was aimed at reducing the exposure to lead for construction workers because of the health implications. The 8-hour Permissible Exposure Limit (PEL) was 50µg/m^3 of airborne lead and employers ensured that no worker exceeded the PEL. It was mandatory that employee were provided with personal protective equipment such as clean coveralls, gloves, hats, shoes or disposable shoe coverlets, face shields and vented goggles, weekly or daily if there was greater than 200 µg/m^3 lead in air (OSHA, 1993). The period gasoline was in use, lead got deposited in the soil, but the lead levels in air emissions decreased as leaded gasoline was banned. Brian-Phillips (2011) also reported that there was an increased risk of exposure to lead for those road construction workers, who worked on roads in highly populated areas. At road construction sites, it was imperative for personnel to wear protective respirators, to ensure workers' blood lead levels were below acceptable limits for lead emissions increased with the number of cars that ply the route. The drop in lead emissions started in 1975 with federal law eliminating the use of leaded gasoline for vehicles.

Reagan (1998) examined data from soil samples taken from sites along U.S. roadsides and found inordinately high levels of lead residue. The work was done in several locations which showed consistent findings. The leaded gasoline emissions contained small particles of lead that got deposited along roadsides. Regan found levels of lead in roadside soil samples were substantially higher than in other areas. Mielke & Reagan (1998) discovered in a research on soil and that it was an important pathway of human lead exposure. Leaded gasoline in soil contaminated agricultural produce used as food. The consumption of lead-contaminated food were strongly associated with population high blood lead levels in both young and old adults. Laidlaw (2008) built upon the work of Mielke & Reagan (1998), reexamined the lead content in soils of urban roadways and the content in soils of corresponding rural areas. Their findings confirmed an increased risk.

Road construction workers were also exposed to crystalline silica which was hazardous to health. Echt (2003) reported that road construction workers got much exposure to crystalline silica and that occupational exposure to crystalline silica was a universal problem. In addition, that the underground workers, with an average 8-hour exposure, had the highest risk of exposure while the boilermakers had the least exposure to crystalline silica. Linch (2002) reported that National Institute for Occupational Safety and Health (NIOSH) visited construction to obtain data between 1992 and 1998 and got an alarming result. NIOSH (2001) reported that prolonged exposure to respirable dust containing crystalline silica may cause silicosis, a lung disease characterised by progressive fibrosis of the lungs. Galloway (2007) reported that the disturbing association of prolonged exposure of workers to crystalline silica and the resultant debilitating disease silicosis led to the establishment of a program in 2005 by NIOSH in the United States, called 'Elimination of Silicosis in the Americas.' The European Union (EU, 2001) were also concerned with the importance of the elimination of Silicosis, published in its official journal a good practices guide for handling crystalline silica and its products in 2006. NIOSH (2013) also requested that editors of trade journals, safety and health officials must alert workers who were at risk. Linch (2002) also reported on respirable concrete dust-silicosis hazard in the construction industry that various activities in the industry produced copious amount of fine dust that caused the debilitating and fatal lung disease, silicosis. David (2004) reported in the research on highway repair that there was a strong relationship of exposure to silica and construction on the highway. The New Jersey Department of Transportation (NJDOT, 1997) sampled the air hygiene at highway repair sites and found out that workers were at risk.

Workers in road construction were exposed to occupational noise hazard in roadways. Onuu (1992) carried out a research on 'Measurements and analysis of road traffic noise and its impact in parts of South Eastern Nigeria' found that Aba and Uyo had high noise pollution values. Occupational noise hazard in roadways and traffic intersections affected people working in the busiest of street environments and were often exposed to high levels of noise and were at risk of noise-induced auditory and psychological health effects. There was a shortage of data in South-Eastern Nigeria, to realistically estimate the occupational noise exposure levels and, as a result, there were no reliable and comprehensive estimated `noise-induced health hazards. Saadu (2010) reported that most studies regarding noise pollution in South-Eastern Nigeria were focused on the established spatial baseline at different parts of the states, which were not interpreted from occupational safety and health of the working populations. Ishtiaque (2013) generated an extensive temporal noise exposure database monitoring at different sites and routes in Bangladesh. Noise exposure metrics were calculated, which made obvious the level of the noise-exposure compared to the permitted noise exposure levels in the Occupational Safety and Health Administration (OSHA) and NIOSH guidelines. After correction for the working shift, the range of noise exposure was found to be ranging from 88.4dBA to as high as 94.3dBA, and these values were beyond the recommended safe levels of noise exposure. However, the study pointed out the importance of regular assessment of the safety of workers and the environment with noise exposure and emphasised that noise exposure criteria such as those outlined in OSHA or NIOSH guidelines must be adopted to ensure good health and well-being of workers in noisy environments.

2.4 Some occupational and ecotoxicological hazards asphalt industries.

Asphalt was made of complex chemicals and asphalt industry workers were exposed to adverse health effects. NIOSH (2015) reported that at work-sites known carcinogens had been found in asphalt fumes. NIOSH (2014) also reported that fire, explosion and health hazards were the primary hazards associated with asphalt. Distributors of asphalt on roads applied at temperatures above flash point were vulnerable to combustion. The burners must be shut off before the commencement of spraying and traffic warning signs must be posted. U.S. EPA (2011) advised that dry chemical or carbon (IV) oxide extinguishers be stored in the cleanest place on the vehicle and a second extinguisher, also made available. Amanda *et al.* (2017) reported that asphalt would support combustion if overheated in the presence of adequate oxygen supply. Some asphalt types of cement and air-blown asphalts were not combustible until heated above 232 °C (450 °F). The rapid-curing cut-backs were the most susceptible to combustion than the medium-curing cut-backs. Slow-curing cut-backs were the least likely to cause fire. Asphalt types of cement and oxidised asphalts required being heated to high temperatures before transfer and application. NIOSH made recommendations in a document that served as a basis for the identification of future research for the reduction of asphalt occupational exposures. NIOSH, with its labour and industry partners, made great strides in reducing worker exposures to paving and roofing asphalt fumes. Wang (2001) reported that potent carcinogens were contained in crude asphalt. However, specific adverse effects on workers had not been established, on exposure to these mixtures.

The relationship between exposure and damage caused to the carrier of genetic information, deoxyribonucleic acid (DNA) was not clear, but that chronic exposure led to a long-term health effects. A sensitive, selective, and reliable analytical method had been developed and validated for the characterisation of asphalt fumes generated under conditions that simulated road paving sites. The characterisation of the fumes was a useful tool to study the adverse health effects of workers exposed to the hazardous mixtures. Polycyclic aromatic hydrocarbons (PAHs) contained in asphalt were an essential class of chemical hazards. These compounds or their metabolites were interacted with DNA, which resulted in covalent bonding between chemicals and biological macromolecules and an indirect damage to DNA. The information obtained from these studies may assist in risk assessment and the development of prevention strategies for people exposed to such mixtures in the workplace.

2.5 Some occupational and ecotoxicological hazards in brewery industries

There was a broad spectrum of hazards that emanated from brewery industries. These hazards included fire and explosion, mechanical hazards from moving machinery, electrical risks, and biological hazards (allergic reactions to plant), physical hazards (tripping, falling, impact from vehicles or falling objects) and ergonomic hazards (lifting loads or from repetitive operations). Richard (2013) in the study on hazard assessment in the brewing and distilling industries, discovered that ethanol from the production of beer and spirits was highly flammable. Brewers and distillers handle flammable (explosive) materials and were subjected to the national law. A systematic hazard and risk assessment were undertaken which ensured that personnel and the public were not at risk from fire and explosion under the control of the Dangerous Substances Explosive Atmospheres Regulations (DSEAR, 2002). DSEAR was the United Kingdom's implementation of the European Union-wide ATEX directive. ATEX (1999) reported that both the raw ingredients and the finished product could form hazardous explosive atmospheres in the brewing and distilling industries. Maxwell (2004) reported that there was a high probability of a flammable atmosphere in some workplaces, and explosion protection was achievable through the identification of flammable materials and reliable elimination of ignition sources. The grain silos required explosion protection; however, adequate measures were taken to minimise dust control explosion risk. The ignition sensitivity was low when the grain moisture content was high. Extensive zoning of workplaces were avoided, and the accumulation of dust on floors, pipelines, and walls were fuel that waited to be raised into a dust cloud. Increased zone severity, for instance, from non-hazardous to Zone 22 or Zone 21 to cater for layers meant the acceptance of personnel that worked in an explosive atmospheres with dust concentration greater than 50 g/m^3, whereas occupational hygiene levels were in mg/m^3 level. It was desirable that fuel were kept inside the equipment and that well designed, sealed and properly maintained plant were used, with the secondary flexible connections which reduced leakage. The habit of plant being cleaned, sealed and extraction systems improved, which keep off dust clouds. These measures brought enormous benefits to the work environment reduced secondary explosion hazards in the workplace and preserved the equipment. Masson (1998) reported that the elevators, conveyors, and mills were potent sources of mechanical friction and sparks when a malfunction occurs. A preventive maintenance scheme were put in place for all mechanical equipment, which included bucket elevators. Priest (2003) also reported that, hops were used extensively in brewing, for their antibacterial effect, which favoured the brewer's yeast activities Reeb-Whitaker (2014) in a research on respiratory disease associated with occupational inhalation to hop (Humulus lupulus) during harvest and processing, discovered that, various forms of respiratory disorders were associated with hop farming. Hence, occupational exposure to hop dust was associated with respiratory disease and should be handled with caution in brewery.

2.6 Assessment of Occupational and Ecotoxicological Hazards.

2.6.1 Biomarkers: A biomarker was described as a measurable chemical, physical or biological characteristic between a natural system and an environmental agent (WHO, 1993).

2.6.2 Classes of Biomarkers

2.6.2.1 Biomarker of exposure: the interaction of a xenobiotic agent and some target body molecules and the information obtained was complemented by workplace environmental monitoring.

2.6.2.2 Biomarker of effect: a biomarker of effect was described as a measurable biochemical, physiological and behavioural alteration within the body and its magnitude was associated with an established or possible disease. Exposure to genotoxic agents were assessed by the use of biomarker-based approaches and increases of the biomarkers were considered as disease-related early changes. The biomarkers of genotoxicity was used to measure specific occupational and environmental exposures to predict the risk of disease that emanated from genotoxic chemicals (WHO, 2010).

2.6.2.3 Biomarker of susceptibility: reflected the intrinsic characteristics of an organism that make it more liable to be influenced by the adverse effects of an exposure to a specific substance (WHO, 2015).

2.6.3 The assessment of human health risks and exposure to chemicals

2.6.3.1 Hazard identification

Hazard identification was usually the first step used for the identification of the specific chemical hazard and determination of exposure to the chemical and its ability to adversely affect health. The establishment of the identity of the chemical of interest and determination of its hazardous potentials and the extent of the danger to health was the bedrock of hazard identification (WHO, 2010).

2.6.3.1.1 Chemical identity

The chemical identity was conducted with sample collection and chemical analysis of potentially hazardous chemicals and its identification. However, preliminary identification of the chemical of interest was necessary as appropriate laboratory procedure was dependent on the specific chemical (WHO, 2010).

2.6.3.1.2 Hazardous properties

Any of the material's properties that became obvious during, or after, a chemical reaction, was identified as the potential hazard of the chemical and was determined from the scientific data (generally data from toxicological studies) on the chemical to confirm that when the compound, was subjected to certain conditions, was capable of causing an adverse effect in humans (WHO, 2010).

2.6.3.2 Hazard characterisation

Hazard characterisation was aimed at obtaining a comprehensive description of the inherent properties of the hazardous agent to health upon exposure. A description of the distinctive nature of a hazardous agent qualitatively or quantitatively which included the identification of dose-response assessment, such as, a no-observed-adverse-effect level (NOAEL), no-observed-effect level to establish in humans the quantitative relationship between dose and effect (WHO, 2010).

2.6.3.3 Exposure assessment

The exposure assessment was used to determine whether humans were in contact with a potentially hazardous chemical. If there was exposure, the dose-response assessment was carried out, which established the quantitative relationship between dose and effect, route, mode and duration of transmission that identified the definite exposures, in human populations. (WHO, 2010)

2.6.3.4 Risk characterisation

The last step of a chemical risk assessment was a quantitative statement about the estimated exposure compared with the health-based guidance value or another hazard characterization value, such as the cancer slope factor and were dependent on the duration (short-term, medium-term, long-term) and route (oral, inhalation, dermal) of exposure (WHO, 2010). The synthesis of both qualitative and quantitative information from the expected environmental exposure to the estimated danger to human health was the hallmark of risk characterisation. The generation of big data was valuable when paired with clinical evidence. The emerging influence of digital biomarkers made it imperative for the healthcare industry to utilise new technologies to generate and track data. With the wealth of new data, the system turned it into relevant and more precise information that helped researchers, clinicians, entrepreneurs, and consumers to understand states of both disease and health. Workers who made use of smartphones with digital tools had the opportunity to monitor and track their health status in their various work environment. The wrist-worn devices accurately monitored and recorded vital signs over time with minimal effort outside the hospital environment. The data collected and translated into informative, actionable insights which expanded the population that generated health data. Data obtained through traditional medical devises and equipment were excluded. The physiological and behavioural worker-generated data collected through connected digital tools for monitoring workers exposure to hazards in the workplace was vital. About 11 per cent of all mobile phone users and 19 per cent of smartphone owners (Comstock, 2012) used at least one health app, many of which allowed individuals to track various health measures (blood pressure, heart rate, physical activity and sleep).

A high population of individuals around the developed countries had chosen to contribute their data to advance research (McCauley, 2016), and researchers used smartphones to reach a large population of workers. The digital biomarker made it possible to passively and continuously monitor, and collect accurate data of workers exposed to occupational hazards over long periods. The data were on an individual's or group basis and achieved exact professional health management for the workers' population. The creation of digital biomarker panels was the bedrock of digital biomarkers. The boards of both digital and traditional, biomarkers offered an opportunity to better explain variance in human health and disease. However, evaluation and validation of digital biomarkers and the measurement method were in view.

2.6.4 Selection and validation of biomarkers

The selection and validation of biomarkers was the final stage in the development of a biomarker predictive of clinical outcome. The process of selection and validation entailed the specificity and sensitivity of the biomarker as a measure of exposure to the observed adverse health effects (Dobbin *et al*. 2016). Also, the same process was for establishing the exact and quality assurance of the analytical procedure for the measurement of the selected biomarker. The source of the precise chemical of concern may be the air, water, soil or food. The number of host characteristics that can influence response to chemical exposure included previous exposure to the same or other chemicals, age, race, gender, health status and genetic susceptibility.

2.6.4.1 Biomarkers of effect

The biomarkers of effect ranged from biomolecules found in the body fluids such as neutrophils and macrophages in inflammation to physiological measurements such as lung function tests.

2.6.4.2 Haematological biomarkers

A measurable indicator of the physiological condition of some disease state in an organism and useful in making diagnosis of blood diseases. The routine leucocyte, erythrocyte, and thrombocyte counts were used in the monitoring of cancer and benzene-exposed workers (Tunsaringkarn, Soogarun & Palasuwan, 2013).

2.6.4.3 Biomarkers of immunotoxicity

The biomarkers of immunotoxicity involved the immune system protection of the organism against infectious microorganisms. The genetic factors of the organism, age, nutrition, and lifestyle, influenced the immune system. Xenobiotics influenced the immune system, which may be stimulated or suppressed (Mohammad & Swaranjit, 2016). Hypersensitivity reactions after inhalational exposure included asthma, rhinitis, and pneumonitis. Assessment of airway hyperactivity was carried out through challenge tests

(Suojalehto & Cullinan 2014). Inhalational exposure was used and carried out by qualified personnel in carefully controlled environments.

2.6.5 Application of biomarkers

Workers were exposed to complex mixtures which had additive, synergistic, or antagonistic actions. The complexity of exposure scenarios and lack of data made hazard management decisions difficult and time-consuming. Different doses produced widely different responses in human, and some of the answers were of no consequence to health, may be beneficial (antioxidant), or toxic (Holsapple, 2008). Assessment of human exposures to natural and synthetic compounds from work environment, occupation, and lifestyle had their effects relied upon the measurement of the particular substances or biological breakdown products, known as metabolites, in human tissues and body fluids. Biomarkers as measurable indicators of early changes in biological systems were used with data from air monitoring, as the data interpretation required caution about exposure sources and metabolism of the chemicals.

According to Manno (2010), assessment of workers exposure to hazards consists of standardised protocols aimed at the detection of vital signs (biomarkers) which were indicative of exposure effect had three main goals: the individual or collective exposure assessment; the health protection; and the occupational health hazard assessment. When markers of chemical compounds and occupational exposures were isolated from the analysis of biological samples, the effort of prevention of health effects of exposure to hazardous substances was enhanced (Sexton, 2004; CDC, 2005). The indirect measure of human exposure, which contributed to occupational hazard assessment at individual or group level was measurement of the concentration of a chemical, physical or biological hazard in the work environment. Biomarkers were usually more specific and sensitive than most clinical tests, and therefore were more useful for assessing a causal relationship (Manno, 2010)

Chapter three III: Materials and Methods

3.1 Human Subjects

This study consisted of one hundred and thirty-five, female and male human subjects within the ages of twenty-one and sixty (21-60) years from selected industries who participated in the assessment of the health status. From the healthcare industry, the total number of males were fourteen (14) while female participants were twenty-eight (28). Quarry industry had eleven (11) males, while twelve (12) were females. From the road construction industry, there were fifteen (15) males and sixteen (16) females. For the asphalt industry, ten (10) males and an equal number of females participated in the study. The brewery industry had both male and female participants as eight (8) and eleven (11), respectively. The control group for the study were human subjects; seven (7) males and eight (8) females, within the ages of twenty-one and sixty (21-60) years. The control group were non-industrial workers.

3.1.1 Inclusion and Exclusion criteria

The participants were volunteers who had been on the technical work for three years (exposure period) and above. Those who had less exposure period were excluded. The exclusion criteria for the control group were those who were involved with any of these selected industrial activities which got the individual/s exposed for some time, were excluded.

3.2 Ethical clearance

The ethical permit was obtained from the Research Ethics Committee, School of Biological Sciences, Federal University of Technology, Owerri (Appendix 18).

3.3 Study Area

South-Eastern Nigeria, also known as Igboland, a linguistic area in Nigeria that was defined by the Igbo culture and language. Situated in the Lowland forest region of Nigeria.

Igboland with an area of about 15,800 to 16,000 square miles (Edeh, 1985) in Southern Nigeria; made up of Abia, Anambra, Ebonyi, Enugu and Imo States (Uchem, 2001). Igboland had a population density ranging from 1000 people per square mile in high-density areas and 350 per square mile in low-density regions. A rock quarry which was mine for tool and pottery making for a 'stone civilisation' near Ibagwa was uncovered in 1978. Igboland was part of Southern Nigeria Protectorate, created by the British colonialist, which was amalgamated into modern-day Nigeria in 1914. The period 6000 BC anthropologists at the University of Benin discovered fossils and use of monoliths at Ugwelle-Uturu in the Okigwe area. Further evidence was also uncovered of ancient settlements at a hypothesised Nsukka metal cultural area from 3000 BC (Hyginus & Chigere, 2001).

3.3.1 Geographical location

South-Eastern Nigeria was located at Latitude, 6° 26' 59.99" N; Longitude, 7° 29' 59.99" E. The coordinates of Igboland were illustrated in the map on figure 3.1.

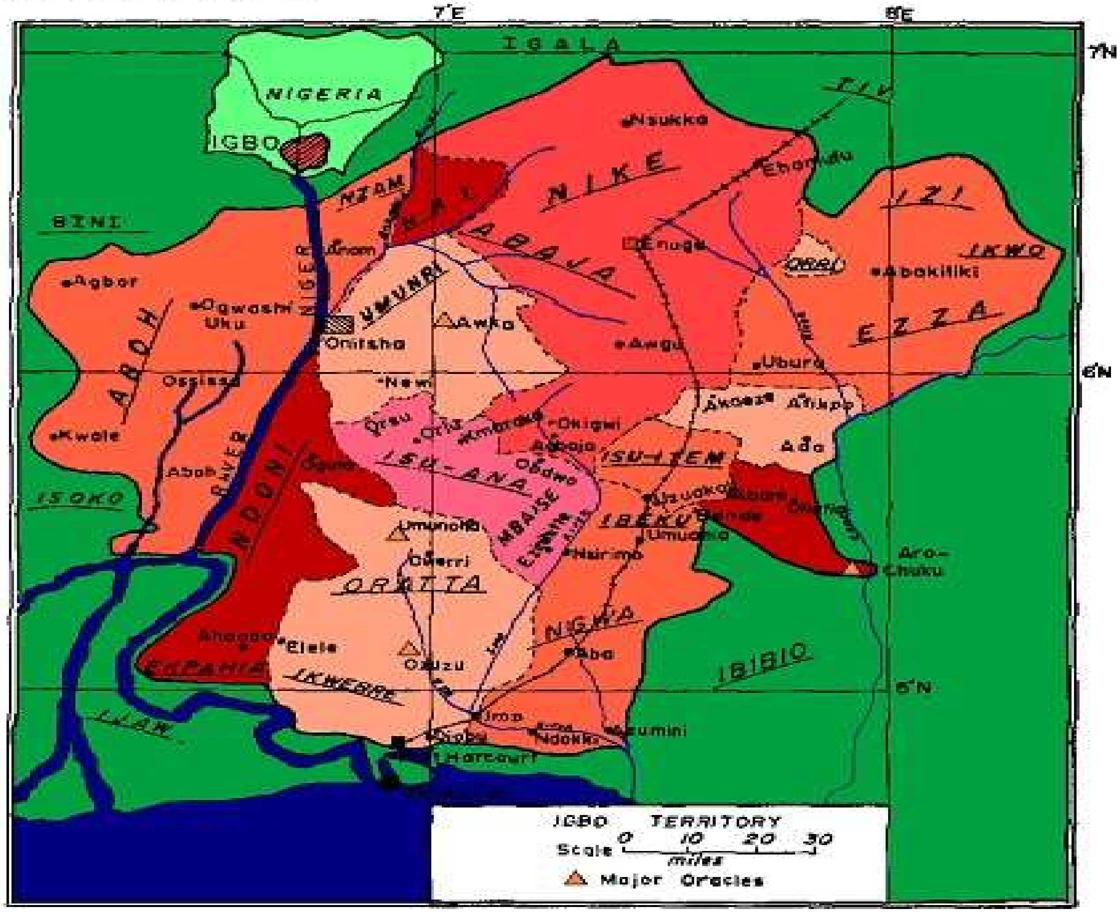

Figure 3.1: Map showing coordinates of Igboland in South-Eastern Nigeria (Monteath & Warner-Lewis, 2007; Chuku, 2005).

Figure 3.2: Map of Igboland (Monteath & Warner-Lewis, 2007; Chuku, 2005) modified by researcher to show areas of research in South-Eastern, Nigeria.

3.4 Population of the study

The total number of workers in healthcare, quarry, road construction, asphalt, and the brewery industries studied were sixteen thousand, three hundred and three (see figure 3.3). A sample size of one hundred and thirty-five workers was taken.

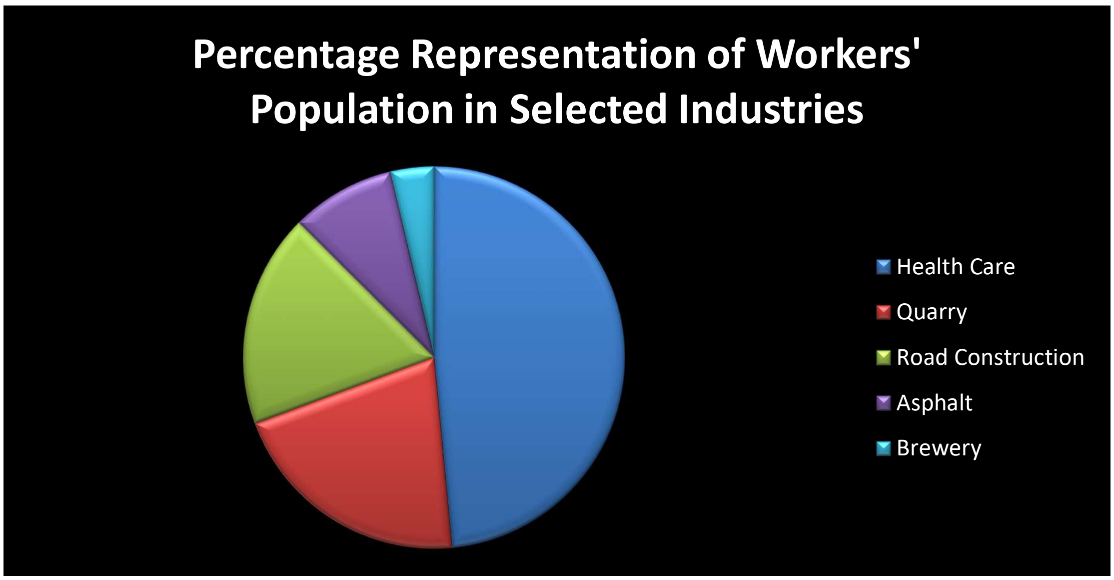

Figure 3.3: Percentage Representation of Workers Population in Healthcare, Quarry, Road Construction, Asphalt and Brewery Industries

3.5 Collection of Radiology Forms /Specimen/Samples

3.5.1 Collection of Radiology forms / Sputum/Blood specimen and hair washings

Human subjects for the study consisted of one hundred and thirty-five male and female industrial workers aged twenty-one to sixty years who volunteered to participate and had been in the job up to three years. The workers and the control subjects for this study were duly clerked with the comprehensive bio-data recorded, past and present medical and surgical history; full observation and recording of the vital signs which included the body temperature, the pulse rate, the respiratory rate, the blood pressure, bowel motion, allergic reactions, family history, reproductive history and occupational history. The clinical examination of the body was sequentially carried out in this order: inspection, palpation, percussion, and auscultation. In the examination of the chest on inspection important information was gathered concerning the physical appearance, presence of cyanosis, finger clubbing, chest structure, respiratory position, respiratory pattern, respiratory rates, whether there was any form of distress, resulting in the use of accessory muscles of respiration. These muscles include the sternocleidomastoid, upper trapezius, and pectoralis major, to ameliorate the condition. Presence of chest or spine deformities as a result of chronic lung disease like in emphysema, pectus excavatum where there was congenital posterior displacement of the lower portion of the sternum. Spine abnormalities with Kyphosis where the chest was bent forward and Scoliosis where the spine was laterally curved. Palpation helped accentuate normal chest excursion, which elicited symmetrical expansion of the lung, for the asymmetric lung expansion that resulted from a pleural effusion. Palpable vibratory sensation to the chest wall, transmitted by the lung known as Tactile Fremitus were elicited when words "Ninety-Nine" was counted. Percussion tone produced a resonant note for normal lung but a dull note in consolidation. This information was duly recorded in a confidential file, and that formed the basic clinical histories that were called up as the need arose before diagnosis. The chest radiograph provided measurable anatomic structures, physiologic information, used in determining the heart size and shape, the pulmonary blood vessels, the lung fields and pathologic features that were presented by the industry workers. Incidence rate of pathologic features was calculated which showed the number of new cases of consolidation of the lung among males/females industrial workers aged 21-60. The calculation of the rates per 1,000 was carried out as:

$$\frac{\text{The number of males/females industrial workers affected with the consolidation of the lung in the age group 21-60}}{\text{the population of males/females age group 21-60}} \text{ multiplied by 1,000}$$

The healthcare worker with cardiac pathology was subjected to a further investigation of an electrocardiogram (ECG) to measure the electrical activity of the heart to aid further management.

3.5.1.1 Collection of Chest radiology forms

The Chest radiotherapy forms bearing the clients' details; the first and last names and date of birth, the examination of the posterior-anterior and lateral views for screening were written.

3.5.1.2 Collection of sputum specimen for pulmonary tuberculosis

The workers to be screened for tuberculosis were given labelled sputum containers and asked to produce sputum specimen early in the morning of the following day as such specimen was more likely to provide a better and reliable result. An early morning, deep cough specimen were collected on three (3) consecutive days, and the sputa were collected within the same 24-hour period, a minimum of eight (8) hours between specimens and minimum specimen volume was two (2) ml. The quality and quantity of the samples were examined by looking at it through the transparent sides of the container. Hands were washed with running water and soap after handling containers with sputum samples. All waste contaminated with sputum were discarded in 10% sodium hypochlorite solution, incinerated and buried.

3.5.1.3 Collection of blood specimen

Blood samples were collected for full blood count and erythrocyte sedimentation rate (ESR) using aseptic technique. The procedure was explained to the client, and after which the client's consent for the procedure to be carried out was obtained. The arm was extended and well-positioned for venipuncture on a firm surface in a downward position with the hand fisted. The tourniquet was applied 3-4 inches above the puncture site, and the place was cleaned with disinfectant which was allowed to air-dry to avoid haemolysis of the specimen. The needle was inserted at less than a 30° angle for the specimen collection of the 4ml blood sample into the specimen bottle with dipotassium salt ethylenediaminetetraacetic acid (K_2EDTA) as an anticoagulant (concentration of 1.5 - 2.2 mg ml^{-1}). The specimen was mixed by gentle inversion 5 to 10 times to allow a complete interaction between blood and anticoagulant. The specimen was labelled with client's details.

3.5.1.4 Collection of hair washings

Strands of hair of workers washed with distilled water and solution collected in a sterile plastic container that was prepared by dipping into 10% HNO_3 for 24 hrs and washed with de-ionised water. The ethical permit was obtained from the appropriate authority before the specimen was collected from workers.

3.5.2 Assessment of gases for air quality

Nitrogen oxides (NOx), Carbon (IV) oxide (CO_2), Carbon (II) oxides (CO), Sulphur (IV) Oxide (SO_2), non-methane volatile organic compounds (NMVOCs) and Particulate matters (PM) within the workplace and adjoining environment were assessed using CROWCON Gasman 11, a personal gas detector which can continuously monitor the level of oxygen or the presence of a single toxic or inflammable gas. Carbon (IV) oxide was sampled using a CROWCON (2014) gasman monitor/analyser, model CE-89/336/EEC, necessary equipment used to perform automatic analysis of ambient air through the use of physical properties and giving cyclic or continuous output signal (Wark, 1998). NESREA (1991) air quality standards were used.

3.5.3 Collection of water and soil samples

Collection of water and soil samples were carried out from available freshwater and soil around the work environment. Control samples were collected in each town from remote areas. The areas were free from any automobile or industrial activities.

3.5.3.1 Collection of water samples

Samples were collected from available water bodies using sterile $2dm^3$ plastic bottles following prescribed procedures. Samples were collected in duplicates from the upstream, midstream (point of discharge) and downstream.

3.5.3.2 Collection of soil samples

Soil samples were collected at a depth of 15cm using sterile lightweight, sturdy Augers, held at the appropriate position. The cores of soil were put into a sterile graded plastic bag and thoroughly mixed for the cores to be broken and were taken in a random pattern across the area being sampled.

3.5.4 Collection of Plant samples

Selected plant samples (safe ones) were collected from the suspected contaminated soil around industrial locations. The plant samples were two species, *Carica papaya* and *Manihot esculenta* leaves. The control sample of *Manihot esculenta* and *Carica papaya* leaves were collected from soil located away from industrial contamination.

3.6 Radiological/Sputum microbiological/Haematological/ Heavy metal analysis of hair washings.

3.6.1 Radiological: Determination of Chest radiograph (model YSX500D).

Both male and non-pregnant female workers were prepared for the radiology examination. The loose gown that would not interfere with the x-ray images was put on. Jewellery, removable dental appliances, eyeglasses and any metal objects were removed. The two views of the chest radiography, the posterior-anterior and lateral views were determined using x-ray machine model YSX500D. The client stood against the image recording plate while the radiographer positioned the client's chest against the image plate with the hands placed on the hips. For the second view, the client's side was against the image plate with arms elevated and asked to hold the breath for few seconds while the x-ray picture was taken to reduce the possibility of a blurred image. The radiographer activated the x-ray machine from the next room. The entire chest x-ray examination, from positioning to obtaining and verifying the film, was completed within 15 minutes.

3.6.2 Sputum microbiological analysis: Determination of *Mycobacterium tuberculosis* by Smear Staining technic using Hot Ziehl – Neelsen Method (Tankeshwar, 2013).

The quality and quantity of the early morning sputum samples were examined by looking at it through the transparent sides of the container. Hands were washed with running water and soap after handling containers with sputum samples. All waste contaminated with sputum were discarded in 10% sodium hypochlorite solution, incinerated and buried. Smears were made on slides before air drying on a staining rack that was placed across in a sink in batches of not more than 12 (including controls). It was ensured that the slides did not touch each other, and there was enough room to flame underneath the slides, a positive and negative control slides were included for every batch staining. The entire slide was flooded with strong carbol fuchsin and later was gently heated until it was steaming and maintained for 3-5 minutes by using intermittent heat. A tap to which a hose was connected was used to rinse slide in a gentle stream of running water until all excess stain was washed off. The slide was flooded with a decolourising solution and left for 3 minutes and rinsed thoroughly with water and excess drained. The slide was flooded with counterstain (methylene blue) and allowed to stay for 3 minutes and cleaned thoroughly with water, excess drained and allowed to air dry. The stained slides were examined with the aid of X100 microscope.

3.6.3 Haematological analysis of blood:

3.6.3.1 Determination of Full blood count (FBC)

The full blood count was determined using the QBC $_{II}$ plus centrifugal haematology system (Vacutainer & Adams, 1987). The haematological parameters that made up the full blood count were Haemoglobin (Hb) and white blood cells (WBC) – total and differential. These were determined using the QBC $_{II}$ plus centrifugal haematology system as described by Vacutainer & Adams (1987). The QBC $_{II}$ plus centrifugal haematology screening system was for obtaining quantitative clinical values from blood in a centrifugal tube and must be performed in an environment with a temperature range of 20° to 32°C. Blood was filled to the line (mark) and samples investigated within 6hours to achieve optimum conditions. The tube was lowered into the rotor slot of QBC centrifuge and balanced. Rotor cover installed, lid closed and then centrifuged for 5 minutes after which the test tube was transferred to QBC reader. The test tube was positioned, so the tip of the cursor points directly to the colour interphase of interest (interphases 1-6). The haematological parameter at the particular interphase showed when the ENTER button was pressed.

Interface 1-Centre of the GREEN closure and RED Cells (white lamp lighted as the ENTER button was pressed to advance to Interface 2).

Interphase 2-Between DARK RED and LIGHT RED layers (white lamplight went off as ENTER button was pressed to advance to Interphase 3).

Interphase 3- Between LIGHT RED and ORANGE-YELLOW layers

Interphase 4-Top of ORANGE-YELLOW layer and bottom of DARK BAND

Interphase 5- Between BRIGHT GREEN and PALE YELLOW layers

Interphase 6-Between PALE YELLOW and TRANSLUCENT GREEN plasma (ENTER button was pressed) to record venous blood haematology parameters. (Principles of the procedure in Appendix 18).

3.6.3.2 Determination of Erythrocyte Sedimentation Rate (ESR)

by Modified Westergren Method (National Committee for Clinical Standards, 1993)

ESR was set up within six hours after collection of blood using Modified Westergren Method as described by the National Committee for Clinical Standards (1993). Pipet was used to add 0.5 ml of 0.85% saline in a labelled 13 x 100 mm test tube. The venous blood specimen was gently mixed with the anticoagulant, 5 to 10 times to allow a complete interaction between blood and anticoagulant. A pipetting device was used to fill the Westergren pipette to the "0" mark (± 1 mm) with the diluted blood sample and placed in a vertical position in the pipette rack for an hour, exactly when the distance (mm) between the meniscus of the plasma and the top of the erythrocytes was read as the ESR.

3.6.4 Determination of heavy metal analysis on hair

Water digestion for heavy metal analysis was carried out before the determination of heavy metal analysis. Measured 50 ml of sterile solutions gotten from the washing of workers strands of hair with distilled water. The solution was digested in a 250 ml conical flask after the addition of 10ml of nitric acid and heated on a hot plate until volume remained 7-12 ml.

The digest was filtered using what-man filter paper, and the volume made up to the mark in a 50 ml volumetric flask and stored in a plastic container for heavy metal analysis. Determination of heavy metal accumulation of lead, cadmium, mercury, arsenic and chromium on hair, was carried out using Atomic Absorption Spectrophotometer (AAS) at the appropriate wavelength.

3.7 Determination of Air quality (CROWCON Gasman 11 Method)

Air Quality (AQ) was determined with CROWCON Gasman 11, which calculated AQ emissions electronically for four (4) different air quality indices, namely: Nitrogen oxides (NOx), Sulphur (IV) Oxide (SO_2), non-methane volatile organic compounds (NMVOCs) and Particulate matters (PM).

CO_2 was determined with CROWCON analyser.

Gasman II, a direct-reading instrument that offered highly visible and audible alarms, as well as data logging capability, was used to measure dust concentration in minutes and displayed same on a chart.

3.8 Physicochemical and microbiological analysis of water and soil samples

3.8.1 Physicochemical analysis of water

3.8.1.1 Determination of pH of water samples

pH was determined using a handheld pH-meter model HI98107 (HANNA). The meter was rinsed in distilled water. The pH-meter was then calibrated using buffer pH 7, and 4 or 10 and rinsed with distilled water. The pH-meter was inserted into the water sample, and 10 minutes after the meter was switched on the stable reading was recorded.

3.8.1.2 Determination of conductivity/ total dissolved solids

Conductivity was determined using a handheld conductivity-meter, model HI98302 (HANNA). The meter was rinsed in distilled water and was then calibrated using potassium chloride solutions at 25°C. It was then switched on and inserted into the 50ml water sample, and conductivity was recorded in µs/cm when the reading became stable.

3.8.1.3 Determination of dissolved oxygen (DO)

The DO was determined using DO-meter HI9146. The DO- meter was calibrated with 5% sodium sulphate. The meter was switched on for about 10 minutes after the insertion of the probe into the sample. The reading was recorded in mg/l.

3.8.1.4 Determination of biochemical oxygen demand (BOD)

The BOD_5 was determined using DO-meter calibrated with 5% sodium sulphate inserted into the sample for about 10 minutes and reading recorded in mg/l (DO_1). The sample was then incubated in a 250ml wrinkle's bottle for five days at 20°C; then, on the fifth day, reading was recorded by inserting the probe again into the sample (DO_5). The difference in the DO_5 and DO_1 was recorded as BOD_5.

$$BOD_5 = DO_1 - DO_5$$

3.8.1.5 Determination of phosphate

Phosphate was determined by amino acid methods (Otter, 2012) using HI83200 multipara-meter bench photometer at a wavelength of 525 mm. Measured 10ml of the water sample was poured into two (2) separate sample cells. One was used for blank to zero the photometer and ten drops of HI93717A-0 molybdate reagent, then the content of one packet of HI93717B-0 phosphate HR reagent B added to the cuvette. It was shaken gently to dissolve and inserted into the cell compartment and timed for 5 minutes. At the end of the countdown, the READ button was pressed to display the result in mg/l of phosphate phosphorus and phosphate.

3.8.1.6 Determination of nitrate

Nitrate was determined by cadmium reduction method using (Margeson, Suggs & Midgett, 1980) HI83200 multipara-meter bench photometer at a wavelength of 525nm. Measured 10ml of the sample was poured into two separate sample cell bottles. One (1) was used as blank to zero the photometer, and one (1) sachet of Nitrate reagent powder pillow was added to the second sample cell bottle and inserted into the cell compartment and timed for 4 minutes and 30 seconds. At the end of the countdown, the READ button was pressed to display the result in mg/l of nitrate and nitrate – nitrogen.

3.8.1.7 Determination of heavy metal using atomic absorption spectrophotometer

The acid digestion of water samples was carried out before the determination of heavy metals contents of the water. Digestion converts all form of metal into a single oxidation state.

3.8.1.7.1 Water digestion for heavy metal analysis

Measured 50ml of water sample was digested in a 250ml conical flask by adding 10ml of nitric acid and heated on a hot plate until volume remained 7-12ml. The digest was filtered using what-man filter paper, and the volume made up to the mark in a 50ml volumetric flask and stored in a plastic container for AAS analysis.

3.8.1.7.2 Atomic absorption spectrophotometric (AAS)

Heavy metal was determined using the method described by Katrina *et al*. (2001). The apparatus**,** FS 240 Varian atomic absorption spectrophotometer, nitrous oxidant gas, acetylene gas, air oxidant gas, distilled water, conical flask with the reagent based on the heavy metal studied. For the determination of lead 1000 ppm lead (Pb) standard solution was used. For the determination of cadmium, 1000 ppm cadmium (Cd) standard solution was used while the 1000 ppm chromium standard solution was used for the determination of chromium. The working standard solutions were prepared through a stepwise dilution of the standard stock solutions using 0.5% (v/v) nitric acid (HNO_3), ammonium phosphate monobasic ($NH_4H_2PO_4$), and magnesium nitrate ($Mg(NO_3)_2$) that were used as chemical modifiers for the determination of the Pb, Cd, Cr (Zhong, Ren & Zhao, 2016). For the determination of Arsenic 1000ppm ±1% ppm standard solution, 1000 mg/l was used. The determination of Mercury requires Mercury (Hg) in 12% nitric acid, prepared with high purity Hg metal, HNO_3 and water. The flask was heated till clear digest was obtained. The digest was filled with distilled water to the 25 ml mark and appropriate dilutions made for each element. The sample was thoroughly mixed by shaking, and 100 ml of it transferred into a glass beaker of 250 ml volume. The sample was aspirated into the oxidising air-acetylene flame or nitrous oxide-acetylene flame. When the aqueous sample was aspirated, the sensitivity for 1% absorption was recorded. (See Appendix 20 for Principles of atomic absorption spectrophotometer).

3.8.2 Determination of microbiological analysis of water by the spread plate method

Microbiological analysis of water samples was determined using the spread plate method, as described by Rijal (2017**).** The spread plate technique resulted in visible and isolated colonies of bacteria were evenly distributed in the plate and were countable.

3.8.2.1 Serial dilution

A series of six (6) test tubes containing 9 ml of sterile distilled water was prepared. In the first tube of the set, 1ml of the sample was added using a sterile pipette and was labelled as 10^{-1}. The test tube was turned upside down for few times to mix the contents thoroughly. 1ml of the sample was taken from the first tube and was transferred to the second tube, which was labelled 10^{-2}. The procedure was repeated with all the remaining test tubes that were labelled until 10^{-6} test tube.

3.8.2.2 Plating

Measured 0.1 ml of diluted sample was pipetted from the appropriate dilution (10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} or 10^{-6}) series and inoculated onto the centre of the surface of an agar plate, nutrient agar plate, sabouraud dextrose agar and mineral salt agar. The L-shaped glass spreader (hockey stick) was dipped into alcohol and flammed over a bunsen burner. The sterile glass spreader was used to spread the sample evenly over the surface of the agar, and the petri dish was carefully rotated underneath at an angle of 45° at the same time. The incubation of the plate was carried out at 37°C for 24 hrs for bacteria and fungi 28±2°C for 78 hrs-96hrs.

The colony-forming units (CFU) value of the sample was calculated. CFU/ml in the original sample determination entailed, the counting of the colonies, multiplied by the appropriate dilution factor. CFU/ml equals (no. of colonies x dilution factor) / volume of culture plate.

3.8.3 Physicochemical analysis of Soil

3.8.3.1 Particle size distribution

The procedures used for soil particle size analysis was hydrometer method (United Arab Emirates university manual*)*. The method was based on the effect of particle size on the differential settling velocities of silt and clay measurement within a water column. Measured 40 g of 2 mm of air-dried soil was weighed in a 600 ml beaker and 60 ml of the dispensing solution was added and the beaker was covered with a watch glass and left overnight. The content of the beaker was then transferred quantitatively into a stirring soil cup filled up to three-quarter level and stirred at high speed for 3 minutes using special stirrer. The stirring paddle was rinsed into a cup and allowed to stand for 1 minute. Then the suspension was transferred quantitatively into a hydrometer jar and brought to volume with distilled water.

3.8.3.1.1 Determination of blank

Measured 60 ml dispensing solution was diluted with water in a hydrometer jar. The suspension was thoroughly mixed, and hydrometer reading was taken, (R_b).

3.8.3.1.2 Determination of silt and clay

Soil suspension was mixed in a hydrometer jar using special paddle which was carefully withdrawn, and the hydrometer was inserted. The surface of the jar with froth was cleaned. A drop of amyl alcohol was added. Forty seconds after the paddle was withdrawn, the hydrometer reading was taken (R_{sc}). Percentage silt plus clay was calculated using the formula:

$$\% \text{ [silt + clay] (w/w)} = (R_{sc} - R_b) \times \frac{100}{\text{Oven – dry soil (g)}}$$

Where (R_b) = hydrometer reading

(R_{sc}) = hydrometer reading forty seconds after the paddle was withdrawn

3.8.3.1.3 Determination of clay

A sample of soil suspension in the hydrometer jar was mixed with the paddle and withdrawn from the hydrometer jar with care, and the suspension was left undisturbed for 4 hours. Then, the hydrometer was inserted, hydrometer reading (R_c) was taken.

The percentage of clay plus silt was calculated using the formula:

$$\% \text{ clay (w/w)} = (R_c - R_b) \times \frac{100}{\text{Oven – dry soil (g)}}$$

Where:

(R_b) = hydrometer reading

(R_{sc}) = hydrometer reading 4 hours after the paddle was withdrawn.

% silt (w/w) {% silt + clay (w/w)} - {% clay (w/w)}

3.8.3.1.3 Determination of sand

The suspension was transferred quantitatively through a 50 µm sieve after the required reading for the silt and clay were taken. The sieve was washed clean. Sand was transferred quantitatively through a 50 µm from a sieve to a 50 ml beaker of a known weight. The sand was allowed to settle in the beaker, and excess water was discarded afterwards. The sand was heated in the beaker at 105°C and was cooled in the desiccators. After that, it was re-weighed. The percentage of sand in the soil was calculated using the formula: % sand (w/w) = sand

$$\text{weight x} \quad \frac{100}{\text{Oven} - \text{dry soil (g)}}$$

Where: weight of sand was calculated by subtracting weight of beaker from the weight of soil and beaker.

Thus: Sand weight (g) = {beaker + sand (g)} – {beaker (g)}

3.8.3.2 Determination of bulk density

Soil bulk density was determined using the Core method of Grossman and Reinsch (2002). The sample was pressed at some distance, to compress the soil in the confined space of the sampler. The sampler and its content were removed carefully without disturbing or loosening the soil it contains. The two cylinders were then separated while retaining the undisturbed soil in the inner cylinder. Any excess soil from the outside the ring was cut off at the soil surface with a sharp knife. Then the soil sample volume was established to be the same as the volume of the sample holder. The soil was transferred to a container, weighed and placed in an oven at temperature 105°C. The soil sample was weighed and reweighed until a constant weight was achieved. The bulk density was calculated as the weight of dry soil (g) divided by the total soil volume (cm^3). The total soil volume was the combined volume of solids and pores which may contain air or water, or both. A useful indication of a soils physical condition which was easily measured were the average values of air, water and solid in soil.

Therefore:

Bulk density (g/cm3) = Mass of oven dry soil weight (M_s)(g) / Total soil volume (V_t)(cm^3)

Formula: $V_t = \pi r^2 h$ = 22/7.

r = radius, h = height.

3.8.3.3 Determination of porosity

Porosity of the soil was determined using bulk density by the method of Landon (1991). The figure obtained from bulk density and particle density was used in the calculation.

Therefore: Porosity (f) = $(1 – e_o / e_s)$ x 100

Where: f = porosity

e_o = dry bulk density

e_s = particle density

3.8.3.4 Determination of the pH of Soil samples

Measured 1g of each soil sample was dissolved in 1ml of sterile distilled water and used to determine the pH. using pH-meter (pH Spear model)

3.8.3.5 Determination of heavy metals in soil

The acid digestion of soil samples was carried out before the determination of the heavy metals as it can affect the result in environmental analysis.

3.8.3.5.1 Digestion Procedures

Doubly de-ionised water was used to prepare solutions. The sample flasks and digestion vessels were prepared by dipping into 10% HNO_3 for 24hrs and washed with de-ionised water. The procedure converted all forms of metal into a single oxidation state, and de-ionised water was a highly purified water used in laboratory trace analysis.

3.8.3.5.2 EPA Method 3050B

Method 3050B was used as the conventional acid extraction method by Arsenic, (1996). Measured 1g of soil sample was placed in a 250ml flask for digestion. The sample was heated to 95°C with 10ml of 50% HNO_3 without boiling. The sample was allowed to cool and refluxed with repeated additions of 65 % HNO_3 till no brown fumes were given off. Then the solution was allowed to evaporate till the volume got reduced to 5 ml. After cooling, 10 ml of 30% H_2O_2 was added slowly without allowing any losses. The mixture was refluxed with 10 ml of 37% HCl at 95°C for 15 minutes (The United States Environmental Protection Agency, 1996). The digestate was filtered through a 0.45 μm membrane paper, after which it was diluted to 100 ml deionised water and stored at 4°C for analyses. The extraction procedure lasted for 180-200 minutes.

Atomic Absorption Spectrophotometer: Spec photometric approach was adopted for the determination of the heavy metals using Atomic Absorption Spectrophotometer (AAS) (Katrina, Miranda, Michael, Espey, David, & Wink, 2001) and levels of Pb, Cd, Hg, As, and Cr was determined using appropriate lamps at appropriate wavelengths.

3.8.4 Determination of microbial populations in the soil sample

The standard spread plate technique was used to estimate the total bacterial and fungal counts of the soil samples. A serial dilution (spread plate method) was carried out with the inoculation in a Nutrient agar plate. Incubation carried out at 37°C within 24hrs for bacteria. The inoculation in a Sabouraud dextrose agar (SDA) plate was used for the fungal count. Incubation was carried out at a temperature of 28±2°C within 78-96hrs for fungi.

3.8.4.1 Enumeration of hydrocarbon utilizing species, using the method of Zajic & Supplission (1972)

The aliquots (0.1 ml) of appropriate dilutions (10^{-4}) of soil samples' suspensions were plated in duplicate onto the mineral salt (MS) medium of Zajic & Supplission (1972). The medium contains the followings: 1.8 g K_2HPO_4, 4.0 g NH_4cl, 0.2 g $MgSO_4.7H_2O$, 1.2 g K_2HPO_4, 0.01 g $FeSO_4.7H_2O$, 0.1g NaCl, 20 g agar per litre of distilled water. Sterile filter paper (Whatman No. 1) saturated with diesel oil were aseptically placed unto the covers of the inoculated inverted plates and then incubated for 5-7 days at 30^0C. Colonies were counted from duplicate plates and the avenge counts were recorded and used for the calculation of colony forming units per gram (CFU/g) of soil (Adieze, 2012).

It is worthy to note that for hydrocarbon utilizing fungi chloramphenicol is added to inhibit bacteria growth.

Mineral Salt Agar: This was modified by Okpokwashii & Okerie (1988) for the isolation of nitrogen – fixing bacteria free living (Azobacter), Rhodococcus, Myxobacteria, Actinomycetes, Bacterial and Fungi hydrocarbon degrading microorganism. The components: NaCl 10.0g /l, $MgSO_4$. $7H_20$ 0.42g/l, KCL 0.29g/l, KH_2PO_4 1.25g/l, $NaNO_3$ 0.42g/l, pH 7.2 were weighed out accordingly and were dissolved in 250 ml of distilled water in a conical flask. The medium was sterilized by autoclaving at 121°C for 15 min under a pressure of 15 PSI. The medium was allowed to cool to 45°C before it was poured into petri-dishes and allowed to set. The isolation of n were carried out by inoculating 1 ml of 10^6 dilution of the samples into the prepared plates.

3.9 Heavy metal and proximate analyses of plants:

3.9.1 Determination of heavy metal in plants

Digestion of the plants was carried out before heavy metal analysis. The dried leaf samples of *Manihot esculenta* and *Carica papaya* were treated with 8 ml HNO_3 and 10 ml H_2O_2, respectively. Then, were mineralised using a Berghof MWS-2 microwave digestion system. After 40 minutes of digestion, the samples were cooled for 30 minutes, and the clear solutions were filtered and brought at 50 ml with distilled deionised water. Flame atomic absorption spectrometry was used to analyse metals concentrations in the final solutions (Barbes, Bărbulescu, Rădulescu, Stihi & Chelarescu, 2014).

3.9.2 Determination of proximate contents of plant sample

Proximate analyses were carried out to establish levels of moisture, ash, crude protein, crude lipid, crude fibre and total carbohydrate after bringing the samples to a uniform size as stipulated by the Association of Officials of Analytical Chemists,17th edition, (AOAC, 2003). Bioaccumulation of heavy metals was determined by using the leaf samples of *Manihot esculenta* and *Carica papaya*. Ash dissolved in distilled water and samples used to assess levels of the heavy metals using Atomic absorption spectrophotometry (AAS) (Katrina *et al.* 2001) as in water samples above.

3.9.2.1 Determination of moisture content (oven-dry method) by AOAC (2005).

The Aluminum dishes were thoroughly washed and dried in the oven at 110°C. They were put inside the desiccator to cool and weighed separately (W_1). The milled plant sample was put into the weighed dish and weight of the dish, and the undried sample was taken W_2. The sample in the dish was dried in the oven at 70°- 80°C for 2 hours and at 100-135°C for the next 4 hours or until the weight was constant (W_3). The sample in the desiccator was cooled and dry weight of sample plus dish taken. The moisture content was calculated as described in the equation below.

$$\% \text{ Moisture} = W_2\text{-}W_3 \times 100 / W_2\text{-}W_1$$

Where; W_1 = Initial weight of the empty crucible

W_2 = Weight of crucible + food sample before drying.

W_3 = Final weight of crucible + food sample after drying.

Total solids (dry matter)

% Total solids (dry matter) = 100% moisture.

3.9.2.2 Determination of ash content using AOAC (2005).

The measured 5g ground and dry sample was weighed in a known weight of crucible (W_1), and both weights of crucible and sample (W_2) obtained before putting in an oven at 100°C, into tarred silica or porcelain crucible. The sample was charred on Bunsen flame inside fume cupboard, to drive off most of the smoke. The sample transferred into a pre-heated muffle furnace at 550°C and left at this temperature for 2hours or until a white or light grey ash resulted. When the residue turned to black, it was moistened with a small amount of water and dried in an oven and the ashing process, repeated. The sample was then cooled in a desiccator and reweighed (W_3)

Calculation:

$$\%\text{Ash (dry basis)} = \text{Weight of ash} \times \frac{100}{\text{Weight of original food}} = W_3\text{-}W_1 \times 100 / W_2\text{-}W_1$$

Where;

W_1 = Initial weight of the empty crucible

W_2 = Weight of crucible + food sample before drying and ashing.

W_3 = Final weight of crucible + ash

3.9.2.3 Determination of crude protein using AOAC (2005).

In the determination of crude protein using the Association of Analytical Chemists (2005) method, the Standard solution 0.1 M HCl was used with concentrated sulphuric acid and Sodium hydroxide solution 40% w/w. Digestion mixture used was potassium sulphate (K_2SO_4) and copper sulphate ($CuSO_4$). Boric acid was used as it captures the ammonia gas, forming an ammonium-borate complex. Measured 40 g of boric acid was dissolved in sufficient distilled water, and the volume made up to 100 ml. The indicator used was Methyl red.

Protein in the samples was determined by the Kieldahl method. Measured 1.0 g of dried sample was weighed and put into a digestion flask containing 15ml concentrated H_2SO_4 and 8g digestion mixture, i.e. K_2SO_4: $CUSO_4$ (8:1). The flask was swirled to mix the contents thoroughly under a running tap. The content in the flask was then placed on a heater to start digestion until the mixture became clear (blue-green). The digest was cooled and transferred to the 100 ml volumetric flask and made up to mark with distilled water. About 10ml of the digest distilled in a Markan still distillation apparatus was added with 10 ml of 0.50 M NaOH for 10 min. The resultant Ammonia (NH_3) was collected using 20ml of 4% boric acid solution as NH_4OH in a conical flask with few drops of modified methyl red indicator. The distillate was filtered against standard 0.1M HCl solution until the appearance of pink colour (S). A blank is run through all steps as above (B). Percentage of the crude protein content of the sample was calculated.

Formula: % Crude protein = 6.25 x % N (*correction factor)

% N = (SB) x N x 0.014 x 100

The weight of the sample x V

Where; S = sample titration reading

B = Blank titration reading

N = Normal of Hcl

V = Volume taken for distillation

0.014 = milliequivalent weight of Nitrogen

3.9.2.4 Determination of crude fat/lipid using AOAC (2005).

The dry extraction method for fat determination consists of extracting dry sample with some organic solvent, since all the solid material, e.g. fats, phospholipids, sterols, fatty acids, carotenoids, pigment, and chlorophyll are extracted as crude fat. Determined of fat by intermittent soxhlet extraction apparatus. Crude was determined by ether extract method using Soxhlet apparatus. Approximately 5 g of the moisture-free sample was wrapped in filter paper, and placed in a fat-free thimble and then introduced into the extractor tube. The clean and dried receiving flask was weighed and filled with petroleum ether and fit into the apparatus. The water and heater were turned on to start extraction. After 4 – 6 syphoning, ether was allowed to evaporate and the flask disconnected before the last syphoning. The flask was transferred into a water bath to evaporate ether, then heated at 105°C for 2 hours before cooling in a desiccator. The flask and content were weighed.

% Crude fat = weight of ether sample x 100 / Weight of sample

3.9.2.5 Determination of fibre content **using AOAC (2005).**

The fibre content was determined using the method described by AOAC (2005). Measured 2 g of the sample was defeated and boiled under Referenceslex for 30 minutes with

200 ml of a solution containing 0.128 g of the H_2SO_4. The solution filtered through linen on a fluted funnel. It was washed with boiling water until the washing was no longer acidic. The residue transferred to a beaker and boiled for 30 minutes with 200 ml of a (0.223 M) NaOH. The final residue was passed through a thin but close pad of washed and ignited asbestos in a Gooch crucible, and later dried in an electric oven and weighed. The sample was incinerated, cooled and weighed.

The loss in weight after incineration x 100, was the percentage of crude fibre.

3.9.2.6 Determination of total carbohydrates (by difference)

By this, the total carbohydrate content of the sample was the percentage remaining after the moisture, ash, lipid, fibre and protein contents had been removed.

Mathematically,

% Total Carbohydrate= 100% - % (Protein + Lipids + Fibre + Ash Content + Moisture Content)

3.9.2.7 Determination of nitrogen-free extract/carbohydrate (Horwitz, 2003) method.

The determination of Nitrogen-free extract (NFE)/carbohydrate was calculated using the method described by Horwitz (2003). Nitrogen-free extract (NFE)/carbohydrate was calculated by difference as follows:

NFE = 100 - (% Moisture + % Crude protein + % Crude fibre + % Crude fat + % Ash)

3.9.2.8 Determination of energy value using AOAC (2005).

The percentage of calories samples were calculated by multiplying the percentage of crude protein and carbohydrates with four (4) and crude fat with nine (9) (Kjeldahl method). The values were converted to calories per 100 g of the sample.

3.10 Data presentation and analyses

3.10.1 Data presentation

Tables and charts (pie chart, scatter chart, bar chart) were used for data presentations.

3.10.2 Data analyses

Data analyses was carried out using analysis of variance (ANOVA); a hypothesis-testing technique, correlation studies. A significant difference between test groups was accepted at ($p<0.05$).

3.10.3 Statistical analysis of variance (ANOVA)

Statistical analysis ANOVA; a hypothesis-testing technique was used to determine equality between the population mean and that the difference between samples was by chance.

Null hypothesis 1: There was no significant occupational and ecotoxicological hazards associated with healthcare, quarry, road construction, asphalt, and brewery industries. Analysis of variance (ANOVA) single factor was used for the cardiothoracic ratio of the males where the F value was 30.89967146 > F critical value of 2.561124034. In addition, the transverse cardiac diameter of the male workers had the F value as 2526.9499 > F critical value of 2.561124034 with $p < 0.05$. The cardiothoracic ratio of the female workers had F values, 5.45169371 > F critical value of 2.506621016, with $p < 0.05$; more so, for their transverse cardiac diameter, F value was 12.02952327 > F critical value of 2.498918583, with $p < 0.05$, see Appendix 1a (i); Appendix 1a (ii); Appendix 1b (i) and Appendix 1b (ii). Null hypothesis 1 was rejected.

Null hypothesis 2: There was no significant health effect of occupational and ecotoxicological hazards on workers. Analysis of Single Variance Factor was used, where the F value was 7.362068098 > F critical value of 2.546273104 with $p < 0.05$ for the white blood cell (WBC) total count for the male workers. The female workers had F values of 21.2437726 > F critical value of 2.525215102 with $p < 0.05$ for the white blood cell total count, see Appendix 2a and Appendix 2b. Null hypothesis 2 was rejected.

Null hypothesis 3: There was no significant adverse effect of occupational and ecotoxicological hazards on air quality around the work area. ANOVA single factor was used, which showed the difference between samples of SO_2 in air quality of the industries studied. The F value was 17.64957133 > F critical value 3.112249848 with $p < 0.05$ (Appendix 3). The null hypothesis 3 was rejected.

Null hypothesis 4: Industrial toxicants had no significant effects on the physicochemical properties of water and soil around the work environment and adjoining environment. ANOVA single factor showed that the difference between samples were by chance. For physicochemical analysis of water F value was 3.067858 > F critical value which was 1.8602423 (Appendix 4) and single-factor ANOVA for physicochemical analysis of soil, F value was 30.45146 > F critical value which was 2.620654 (Appendix 5) with $p < 0.05$ and Null hypothesis 4 was rejected both for water and soil analysis.

Chapter IV: Results and Discussion

4.1 Results

4.1.1 Demographic data of workers in selected industries.

The total number of one hundred and thirty-five (135) workers, participated in the assessment of the health status of workers in and around selected industries in South-Eastern Nigeria. Age and Gender Distribution of Workers from selected Industries that participated in the Assessment of Health Status, as shown in Table 4.1a. In the healthcare industry, the total number of males was fourteen (14) while female participants were twenty-eight (28) within the age group of twenty-one to sixty (21-60) years. Quarry industry had twenty-three (23) volunteers, out of which eleven (11) were males while twelve (12) were females. The male and female sexes were in the age group of twenty-one to sixty (21-60) years. Workers from the road construction industry were thirty-one (31), and the number of males was fifteen (15) while females were sixteen (16) all within the age group of twenty-one to sixty (21-60) years. In the asphalt industry, ten (10) males and ten (10) females within the age group of twenty-one to sixty (21-60) years were involved in the assessment. The brewery industry had male and female participants as eight (8) and eleven (11), respectively within the age group twenty-one to sixty (21-60) years. The control group was made up of seven (7) males and eight (8) females.

Table 4.1a Age and Gender Distribution of Workers from selected Industries that participated in Assessment of Health Status

	Healthcare		Quarry			Road construction			Asphalt			Brewery			Control		
Age(years)	Gender	No.	Age(years)	Gender	No.	Age(years)	Gender	No.	Age(years)	Gender	No.	Age(years)	Gender	No.	Age(years)	Gender	No.
21-30	Male	1	21-30	Male	1	21-30	Male	2	21-30	Male	2	21-30	Male	2	21-30	Male	2
21-30	Female	2	21-30	Female	4	21-30	Female	3	21-30	Female	1	21-30	Female	1	21-30	Female	3
31-40	Male	2	31-40	Male	4	31-40	Male	6	31-40	Male	4	31-40	Male	2	31-40	Male	1
31-40	Female	11	31-40	Female	4	31-40	Female	4	31-40	Female	4	31-40	Female	4	31-40	Female	2
41-50	Male	9	41-50	Male	3	41-50	Male	5	41-50	Male	3	41-50	Male	3	41-50	Male	2
41-50	Female	4	41-50	Female	3	41-50	Female	6	41-50	Female	4	41-50	Female	3	41-50	Female	1
51-60	Male	2	51-60	Male	3	51-60	Male	2	51-60	Male	1	51-60	Male	1	51-60	Male	2
51-60	Female	11	51-60	Female	1	51-60	Female	3	51-60	Female	1	51-60	Female	3	51-60	Female	2
	Total	42		Total	23		Total	31		Total	20		Total	19		Total	15

4.1.2 Results of health status of workers in selected industries

4.1.2.1 Results of chest x-ray and sputum test for *acid-fast bacilli* of male and female workers in the healthcare industry, Owerri.

The result of chest x-ray and sputum test for *acid-fast bacilli* of male and female workers in the healthcare industry, Owerri are shown in Tables 4.1b (i) and 4.1b (ii). The average value of the cardiothoracic ratio recorded for the male workers was 0.40±0.08 cm and 0.35±0.06 cm for the female workers. The ratio was correlated with the age of the workers, which was illustrated in Figure 4.1a. The correlation coefficient was -0.316227766 and 0.894427191 for the male and female workers, respectively. The mean values of transverse cardiac diameter recorded were 15.38±0.10 cm for the male and 14.30±0.12 cm for the female workers. The chest x-ray of the healthcare workers appeared normal where the mediastinum in posterior-anterior view of the chest x-ray had centrally located position as well as the trachea except for the mortuary attendant male worker with the enlarged left atrium. The normal right atrium, the ascending aorta and superior vena cava were contained in the right contour of the mediastinum. The right ventricle partially overlaid the left ventricle. The left atrium was located inferior to the left pulmonary hilum. The left ventricle prominently rounded apex of the heart and great vessels were viewed as frontal projection. The mortuary attendant male worker had enlarged left atrium, which became directly visible that, the right side pushed into the adjacent lung, and seen beyond the normal right heart border (known as an atrial escape) and had a similar appearance to that caused by the right superior pulmonary vein without atrial enlargement. The diagonal measurement from the midpoint of left main bronchus to the right border of the left atrium more than 7 cm (convex left atrial appendage) was significant and was the most positive sign on chest radiography. There was an increase in the tracheal bifurcation angle (formed by the central axis of the left and right main bronchi) to over 90 degrees.

On the lateral view of the chest x-ray, the left pulmonary artery was seen coursing superiorly and posteriorly relative to the right side of the mediastinum while the left ventricle slopped inferiorly. There was no evidence of mitral stenosis, chronic obstructive pulmonary disease, atelectasis or lung parenchyma involvement with fine or coarse reticular opacities or small nodules. The workers' with normal chest x-ray: lung borders; thoracic spine, neck costophrenic angles, lung apices, retrocardiac space, and retrosternal space had no areas of opacities for infiltrates or masses. The workers' chest x-ray were marked by induration of a customarily aerated lung which was considered a radiologic sign of consolidation. The consolidation of the lung affected 71(7%) of the workers out of which 24% were males while 48% were females, between the age groups of 31-60 years. The consolidation of the lung was correlated with the age of workers as illustrated in Figure 4.1b. The correlation coefficient was 0.25819889 and 0.447213595 for the male and female workers, respectively.

From the sputum samples (x 3), there were no rod-shaped bacteria (bacilli), seen per hundred (100) fields under the microscope after the staining procedure. The results were negative to *Mycobacterium tuberculosis* for all the workers that participated in the healthcare industry.

Table 4.1b (i): Chest x-ray and sputum of male workers in healthcare industry, Owerri

Age group	Sex	No.	Chest X-Ray												Sputum	
(years)			HSS		PBV	Lung Field		Lung borders								
								Diaphragm			Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Male	1	0.5	15.5	0	1	0	1	0	1	0	1	0	1	0	1
31-40	Male	2	0.3	15.3	0	2	0	2	0	2	0	2	0	2	0	2
41-50	Male	9	0.4	15.3	0	9	1	8	0	9	0	9	0	9	0	9
51-60	Male	2	0.4	15.4	0	2	0	2	0	2	0	2	0	2	0	2
Mean			0.40	15.38	0.00	3.50	0.25	3.25	0.00	3.50	0.00	3.50	0.00	3.50	0.00	3.50
Standard deviation			0.08	0.10	0.00	3.70	0.50	3.20	0.00	3.70	0.00	3.70	0.00	3.70	0.00	3.70

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels, LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, *AFB - Acid-fast bacilli.*

Table 4.1b (ii): Chest x-ray and sputum of female workers in healthcare industry, Owerri

Age group (years)	Sex	No.	Chest X-Ray												Sputum	
			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Female	2	0.3	14.2	0	2	0	2	0	2	0	2	0	2	0	2
31-40	Female	11	0.3	14.2	0	11	1	10	0	11	0	11	0	11	0	11
41-50	Female	4	0.4	14.4	0	4	0	4	0	4	0	4	0	4	0	4
51-60	Female	11	0.4	14.4	0	11	1	10	0	11		11	0	11	0	11
Mean			0.35	14.30	0.00	7.00	0.50	6.50	0.00	7.00	0.00	7.00	0.00	7.00	0.00	7.00
Standard deviation			0.06	0.12	0.00	4.69	0.58	4.12	0.00	4.69	0.00	4.69	0.00	4.69	0.00	4.69

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels, LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, *AFB - Acid-fast bacilli.*

Figure 4.1a: Correlation of cardiothoracic ratio with the age of the workers in the healthcare industry.

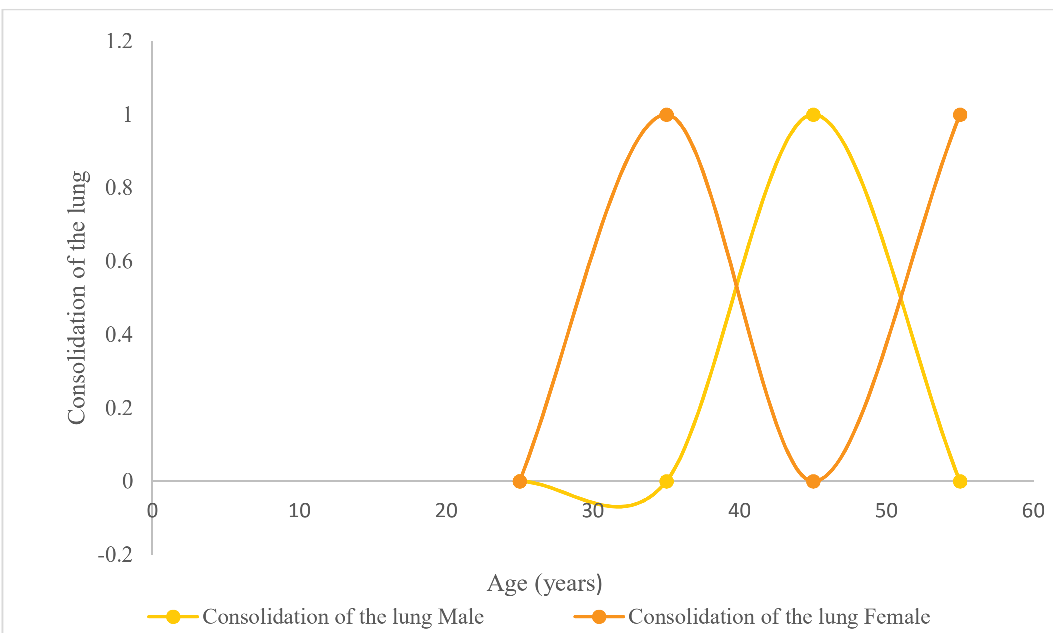

Figure 4.1b: Correlation of consolidation of the lung with the age of the workers in the healthcare industry.

4.1.2.2 Results of full blood count and erythrocyte sedimentation rate (ESR) of the male and female workers in healthcare industry, Owerri.

In Table 4.1c (i), the mean values of full blood count and erythrocyte sedimentation rate (ESR) of the male workers in the healthcare industry are shown. Male workers had an average value of 67.56±2.98% for haemoglobin. The mean values of white blood cells total count recorded was 5742.86±814.03 mcl. For the direct count, neutrophils were 48.64±2.68%; lymphocyte, 42.50±2.77%; monocytes, 3.07±0.83%; basophils, 0.00±0.00%; and eosinophils, 5.42±2.71%. The average value of erythrocyte sedimentation rate for healthcare male workers was 54.50±8.30 mm/hr.

Table 4.1c (ii) shows the mean values of full blood count and erythrocyte sedimentation rate (ESR) of the female workers in the healthcare industry. Female workers had an average value of 64.06±2.46% for haemoglobin. The mean values of white blood cells total count recorded was 5825.00±545.89 mcl. For the direct count, neutrophils were 48.25±3.92%; lymphocyts, 42.87±1.41%; monocytes, 2.87±062%; basophils, 0.25±0.77%; and eosinophils, 6.00±3.14%. The average value of erythrocyte sedimentation rate for female healthcare workers was 62.63±30.19 mm/hr.

Table 4.1c (i): Full blood count and erythrocyte sedimentation rate (ESR) of male workers in healthcare industry, Owerri

Age group (years)	Sex	No.	Full Blood Count							Erythrocyte Sedimentation Rate (mm/hr.)
			Haemoglobin	White Blood Cell						
			(g/dl)	Total count	Direct count					
				(mcl)	Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)	
21-30	Male	1	72.5	6100	49	40	3	0	0	73
31-40	Male	2	66	6200	47	43	3.5	0	6.5	50
41-50	Male	9	66.6	5511.11	48.91	42.67	3	0	4.00	52.22
51-60	Male	2	71	6150	48.5	42.5	2.5	0	6.5	62.5
Mean / Standard deviation			67.56±2.98	5742.86±814.03	48.64±2.68	42.50±2.77	3.07±0.83	0.00±0.00	5.42±2.71	54.50±8.30
Control	Male		76.43±6.65	5485.71±61	49.57±1.72	39.29±6.40	2.14±1.57	0.00±0.00	4.86±0.00	22.14±1.86
Normal range: FBC and ESR.	Male		14-18g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%	0-22mm/hr.

Table 4.1c (ii): Full blood count and erythrocyte sedimentation rate (ESR) of female workers in healthcare industry, Owerri

Age group (years)	Sex	No.	Full Blood Count							Erythrocyte Sedimentation Rate (mm/hr.)
			Haemoglobin	White Blood Cell						
			(g/dl)	Total count	Direct count					
				(mcl)	Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)	
21-30	Female	2	60	6050	47.5	43.5	3	0	6	54
31-40	Female	11	64	5781.82	47.09	42.91	2.91	0.36	6.55	70.27
41-50	Female	4	66	6100	48.5	42.25	2.50	0	7.25	46
51-60	Female	11	67.91	6118.18	48.36	42.27	2.45	0	6.55	55.64
Mean / Standard deviation			64.06±2.46	5825.00±545.89	48.25±3.92	42.87±1.41	2.87±062	0.25±0.77	6.00±3.14	62.63±30.19
Control	Female		69.25±7.72	4887.50±343.08	47±3.81	42.12±083	3.13±0.99	0.00±0.00	4.62±1.60	24.13±1.81
Normal range: FBC and ESR.	Female		12-16g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%	0-29mm/hr.

4.1.2.3 Results of chest x-ray and sputum of male and female workers in the quarry industry, Ishiagu.

Table 4.1d (i) and 4.1d (ii) shows the chest x-ray and sputum of male and female workers in the quarry industry, Ishiagu. The average value of the cardiothoracic ratio was 0.35±0.06 cm for the male workers was and 0.33±0.05 cm for the female workers. The ratio was correlated with the age of the workers, which is illustrated in Figure 4.1c and correlation coefficient of 0.894427191 and 0.774596669 were for the male and female workers, respectively. The transverse cardiac diameter mean values were 15.35±0.13 cm for the male and 14.25±0.10 cm for the female workers. The mediastinum in posterior-anterior view of the chest x-ray had a centrally located position, as well as the trachea. The right atrium, the ascending aorta and superior vena cava were contained in the right contour of the mediastinum. The right ventricle partially overlaid the left ventricle. The left ventricle prominently rounded apex of the heart and great vessels were viewed as frontal projection. On the lateral view of the chest x-ray, the left pulmonary artery was seen coursing superiorly and posteriorly relative to the right side of the mediastinum while the left ventricle slopped inferiorly.

The workers' with normal chest x-ray: lung borders; thoracic spine, neck costophrenic angles, lung apices, retrocardiac space, and retrosternal space had no areas of opacities for infiltrates or masses. The workers' chest x-ray were marked by induration of a normally aerated lung which was considered a radiologic sign of consolidation of the lungs and affected, 87(9%) of the male and 43(4%) of the female workers in the age group 21-50 years. The consolidation of the lung was correlated with the age of workers and was illustrated in figure 4.1d. The correlation coefficient was zero (0) and -0.774596669 for the male and female workers, respectively.

From the sputum samples (x 3), there were no rod-shaped bacteria (bacilli) that was seen per hundred (100) fields under the microscope after the staining procedure. The results were negative to *Mycobacterium tuberculosis* for all the workers that participated in the quarry industry.

Table 4.1d (i): Chest x-ray and sputum of male workers in quarry industry, Ishiagu

Age group (years)	Sex		Chest X-Ray												Sputum	
			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Male	1	0.3	15.2	0	1	0	1	0	1	0	1	0	1	0	1
31-40	Male	4	0.3	15.3	0	4	1	3	0	4	0	4	0	4	0	4
41-50	Male	3	0.4	15.4	0	3	1	2	0	3	0	3	0	3	0	3
51-60	Male	3	0.4	15.5	0	3	0	3	0	3	0	3	0	3	0	3
Mean			0.35	15.35	0.00	2.75	0.50	2.25	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
Standard deviation			0.06	0.13	0.00	1.26	0.58	0.96	0.00	1.26	0.00	1.26	0.00	1.26	0.00	1.26

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels,

LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, *AFB - Acid-fast bacilli.*

Table 4.1d (ii): Chest x-ray and sputum of female workers in quarry industry, Ishiagu

Age group (years)	Sex		Chest X-Ray												Sputum	
			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Female	4	0.3	14.2	0	4	1	3	0	4	0	4	0	4	0	4
31-40	Female	4	0.3	14.2	0	4	0	4	0	4	0	4	0	4	0	4
41-50	Female	3	0.3	14.2	0	3	0	3	0	3	0	3	0	3	0	3
51-60	Female	1	0.4	14.4	0	1	0	1	0	1	0	1	0	1	0	1
Mean			0.33	14.25	0.00	3.00	0.25	2.75	0.00	3.00	0.00	3.00	0.00	3.00	0.00	3.00
Standard deviation			0.05	0.10	0.00	1.41	0.50	1.26	0.00	1.41	0.00	1.41	0.00	1.41	0.00	1.41

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels,

LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, *AFB - Acid-fast bacilli.*

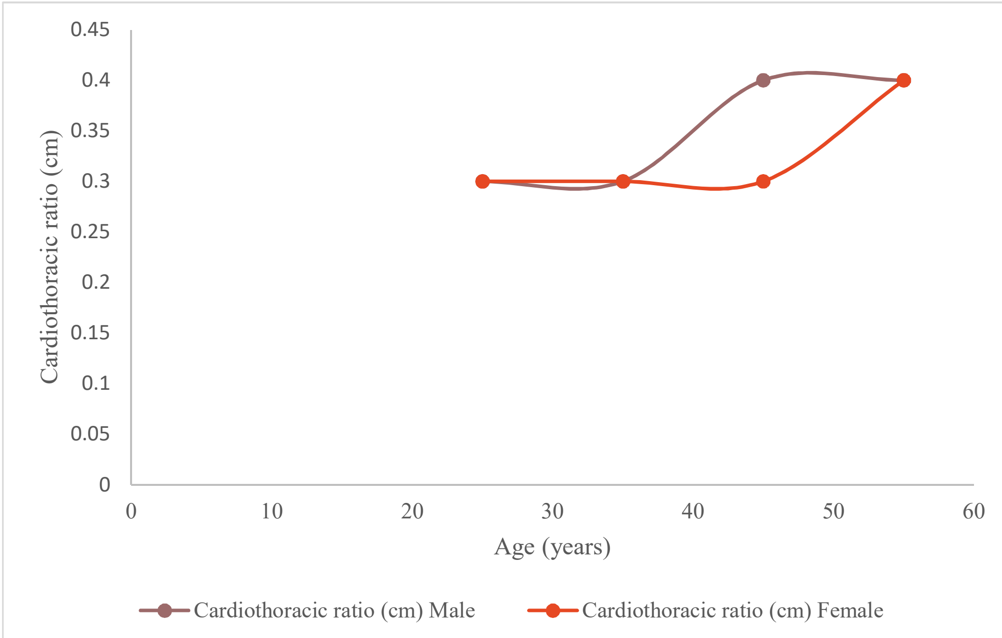

Figure 4.1c: Correlation of cardiothoracic ratio with the age of the workers in the quarry industry.

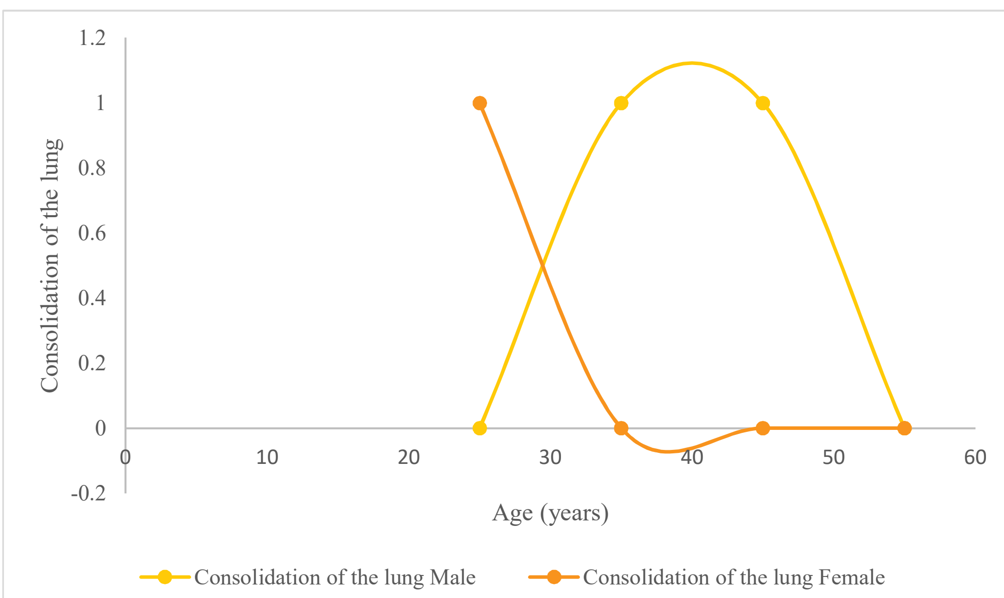

Figure 4.1d: Correlation of consolidation of the lung with the age of the workers in the quarry industry.

4.1.2.4 Results of full blood count and erythrocyte sedimentation rate (ESR) of male and female workers in quarry industry, Ishiagu.

In Table 4.1e (i), the mean values of full blood count and erythrocyte sedimentation rate (ESR) of male workers in quarry industry at Ishiagu were shown. Male workers had an average value of 71.45±9.03% for haemoglobin. The mean value of white blood cells total count recorded was 5272.72±473.48 mcl. For the direct count of white blood cells, the mean values were: neutrophil, 48.00±2.37%; lymphocyte, 42.55±1.51%; monocytes, 2.63±0.67%; basophils, 0.00±0.00%; and eosinophil, 6.81±2.40%. The average value of erythrocyte sedimentation rate for quarry workers was 71.45±20.97 mm/hr.

Table 4.1e (ii) shows the mean values of full blood count and erythrocyte sedimentation rate (ESR) of female workers in the quarry industry at Ishiagu. Female workers had an average value of 66.00±12.74% for haemoglobin. The mean values of white blood cells total count recorded were 4900.00±575.26 mcl. For the direct count, neutrophil were 48.33±2.93%; lymphocytes, 42.58±1.68%; monocytes, 2.58±0.99%; Basophils, 0.00±0.00%; and eosinophil, 5.91±2.50%. The average value of erythrocyte sedimentation rate for quarry workers was 55.75±30.62 mm/hr.

Table 4.1e (i): Full blood count and erythrocyte sedimentation rate (ESR) of male workers in quarry industry at Ishiagu

Age group	Sex	No.	Full Blood Count							Erythrocyte Sedimentation Rate (mm/hr.)
(years)			Haemoglobin	White Blood Cell						
			(g/dl)	Total count	Direct count					
				(mcl)	Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)	
21-30	Male	1	85	5800	53	42	3	0	2	50
31-40	Male	4	64.75	5200	47.25	41.75	2.75	0	8.25	56.5
41-50	Male	3	72.33	5700	49.33	42.33	3	0	5	75
51-60	Male	3	75	5100	46	44	2	0	8	95
Mean / Standard deviation			71.45±9.03	5272.72±473.48	48.00±2.37	42.55±1.51	2.63±0.67	0.00±0.00	6.81±2.40	71.45±20.97
Control	Males		76.43±6.65	5485.71±61	49.57±1.72	39.29±6.40	2.14±1.57	0.00±0.00	4.86±0.00	22.14±1.86
Normal range: FBC and ESR.	Male		14-18g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%	0-22mm/hr.

Table 4.1e (ii): Full blood count and erythrocyte sedimentation rate (ESR) of female workers in quarry industry, Ishiagu

Age group	Sex	No.	Full Blood Count							Erythrocyte Sedimentation Rate (mm/hr.)
(years)			Haemoglobin	White Blood Cell						
			(g/dl)	Total count	Direct count					
				(mcl)	Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)	
21-30	Female	4	68	5075	46.75	42.25	3	0	6.75	60.5
31-40	Female	4	63.75	4775	49.25	42	2	0	5.75	53.5
41-50	Female	3	66	5033.33	48	44	3	0	5.67	64.33
51-60	Female	1	70	4900	52	42	3	0	4	20
Mean / Standard deviation			66.00±12.74	4900.00±575.26	48.33±2.93	42.58±1.68	2.58±0.99	0.00±0.00	5.91±2.50	55.75±30.62
Control	Female		69.25±7.72	4887.50±343.08	47±3.81	42.12±083	3.13±0.99	0.00±0.00	4.62±1.60	24.13±1.81
Normal range: FBC and ESR.	Female		12-16g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%	0-29 mm/hr.

4.1.2.5 Results of chest x-ray and sputum of male and female workers in road construction industry, Owerri.

Table 4.1f (i) and 4.1f (ii) shows the chest x-ray and sputum of male and female workers in road construction industry, Owerri. The average value of the cardiothoracic ratio recorded for the male workers was 0.45±0.06 cm, and for the female workers was 0.40±0.08 cm. The ratio was correlated with the age of the workers, which was illustrated in figure 4.1e. The correlation coefficient was 0.894427191 for the male and 0.948683298 for the female workers. The transverse cardiac diameter mean values of 15.30±0.08 cm and 14.25±0.10 cm were recorded for the male and female workers, respectively. The mediastinum in posterior-anterior view of the chest x-ray had a centrally located position, as well as the trachea. The right atrium, the ascending aorta and superior vena cava were contained in the right contour of the mediastinum. The right ventricle partially overlaid the left ventricle. The left atrium was located inferior to the left pulmonary hilum. The left ventricle prominently rounded apex of the heart and great vessels were viewed as frontal projection. On the lateral view of the chest x-ray, the left pulmonary artery was seen coursing superiorly and posteriorly relative to the right side of the mediastinum while the left ventricle slopped inferiorly. There was no evidence of mitral stenosis, chronic obstructive pulmonary disease, atelectasis or lung parenchyma involvement with fine or coarse reticular opacities or small nodules.

The workers' with normal chest x-ray: lung borders, thoracic spine, neck costophrenic angles, lung apices, retrocardiac space, and retrosternal space had no areas of opacities for infiltrates or masses. The workers' chest x-ray were marked by induration of a normally aerated lung which was considered a radiologic sign of consolidation of the lung and affected 161 (16%) of male and 129 (13%) of female workers between the age groups, 21-60years. The consolidation of the lung was correlated with the age of workers and was illustrated in Figure 4.1f. The correlation coefficient was 0.25819889 and -0.63245553 for the male and female workers, respectively.

From the sputum samples (x 3), there were no rod-shaped bacteria (bacilli) that was seen per hundred (100) fields under the microscope after the staining procedure. The results were negative to *Mycobacterium tuberculosis* for all the workers that participated in health status investigation in road construction industry.

Table 4.1f (i): Chest x-ray and sputum of male workers in road construction industry, Owerri

Age group (years)	Sex	No.	Chest X-Ray												Sputum	
			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR(cm)	TCD(cm)	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Male	2	0.4	15.2	0	2	1	1	0	2	0	2	0	2	0	2
31-40	Male	6	0.4	15.3	0	6	1	5	0	6	0	6	0	6	0	6
41-50	Male	5	0.5	15.3	0	5	2	3	0	5	0	5	0	5	0	5
51-60	Male	2	0.5	15.4	0	2	1	1	0	2	0	2	0	2	0	2
Mean			0.45	15.30	0.00	3.75	1.25	2.50	0.00	3.75	0.00	3.75	0.00	3.75	0.00	3.75
Standard deviation			0.06	0.08	0.00	2.06	0.50	1.91	0.00	2.06	0.00	2.06	0.00	2.06	0.00	2.06

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels,

LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, *AFB - Acid-fast bacilli.*

Table 4.1f (ii): Chest x-ray and sputum of female workers in road construction industry, Owerri

Age group (years)	Sex	No.	Chest X-Ray												Sputum	
			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR(cm)	TCD(cm)	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Female	3	0.3	14.2	0	3	1	2	0	3	0	3	0	3	0	3
31-40	Female	4	0.4	14.2	0	4	2	2	0	4	0	4	0	4	0	4
41-50	Female	6	0.4	14.2	0	6	1	5	0	6	0	6	0	6	0	6
51-60	Female	3	0.5	14.4	0	3	0	3	0	3	0	3	0	3	0	3
Mean			0.40	14.25	0.00	4.00	1.00	3.00	0.00	4.00	0.00	4.00	0.00	4.00	0.00	4.00
Standard deviation			0.08	0.10	0.00	1.41	0.82	1.41	0.00	1.41	0.00	1.41	0.00	1.41	0.00	1.41

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels,

LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, *AFB* - *Acid-fast bacilli.*

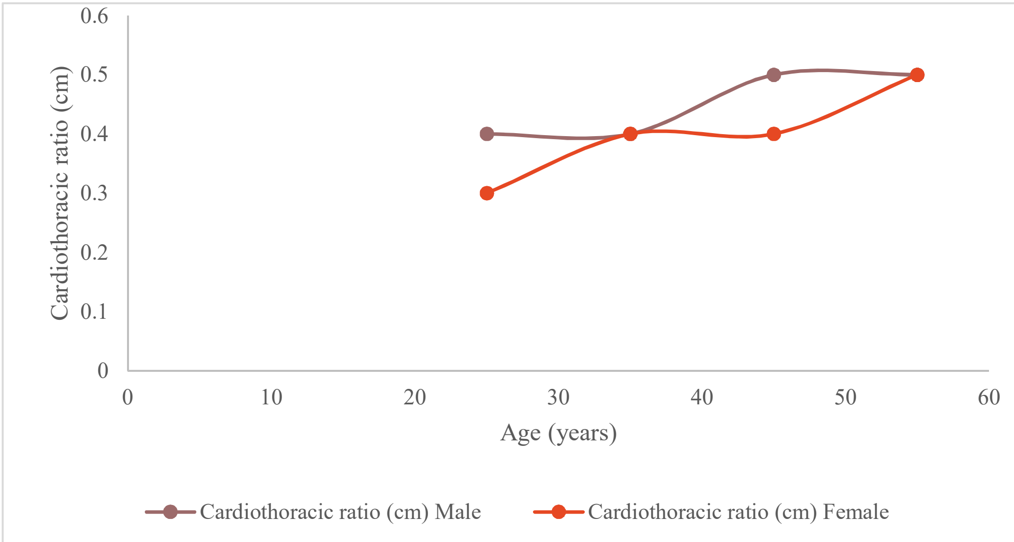

Figure 4.1e: Correlation of cardiothoracic ratio with the age of the workers in road construction industry.

Figure 4.1f: Correlation of consolidation of the lung with the age of the workers in road construction industry.

4.1.2.6 Results of full blood count and erythrocyte sedimentation rate (ESR) of male and female workers in road construction industry in Owerri.

Table 4.1g (i) shows the mean values of full blood count and erythrocyte sedimentation rate (ESR) of male workers in road construction industry in Owerri. Male workers had an average value of 71.00±9.99% for haemoglobin. The mean value of white blood cells total count recorded was 44915.47±416.44 mcl. For the direct count, the mean values were neutrophil, 49.40±3.04%; lymphocyte, 42.80±1.27%; monocytes, 2.87±1.19%; basophils, 2.67±3.97%; and eosinophil, 4.93±2.40%. The average value of erythrocyte sedimentation rate for road construction male workers was 53.67±23.18 mm/hr.

Table 4.1g (ii) shows the full blood count and erythrocyte sedimentation rate (ESR) of female workers in road construction industry in Owerri. Female workers had an average value of 66.19±10.08% for haemoglobin. The mean values of white blood cells total count recorded was 4693.75±329.58 mcl. For the direct count, neutrophils were 46.65±3.17%; lymphocyte, 43.31±2.06%; monocytes, 2.62±0.62%; basophils, 0.00±0.00%; and eosinophil, 5.94±2.11%. The average value of erythrocyte sedimentation rate for road construction female workers was 70.69±28.65 mm/hr.

Table 4.1g (i) Full blood count and erythrocyte sedimentation rate (ESR) of male workers in road construction industry, Owerri

Age group	Sex	No.	Full Blood Count								Erythrocyte Sedimentation Rate (mm/hr.)
(years)			Haemoglobin	White Blood Cell							
			(g/dl)	Total count	Direct count						
				(mcl)	Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)		
21-30	Male	2	72	4950	49	43	3	0	6.5		55
31-40	Male	6	76	5016.67	50.5	42.67	2.33	0	4.5		40.33
41-50	Male	5	71	4680	49.8	42	2.6	8	5		56.6
51-60	Male	2	55	5166	45.5	45	5	0	4.5		85
Mean / Standard deviation			71.00±9.99	4915.47±416.44	49.40±3.04	42.80±1.27	2.87±1.19	2.67±3.97	4.93±2.40		53.67±23.18
Control	Males		76.43±6.65	5485.71±61	49.57±1.72	39.29±6.40	2.14±1.57	0.00±0.00	4.86±0.00		22.14±1.86
Normal range: FBC and ESR.	Male		14-18g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%		0-22 mm/hr.

Table 4.1g (ii): Full blood count and erythrocyte sedimentation rate (ESR) of female workers in road construction industry, Owerri

Age group	Sex	No.	Full Blood Count							Erythrocyte Sedimentation Rate (mm/hr.)
(years)			Haemoglobin	White Blood Cell						
			(g/dl)	Total count	Direct count					
				(mcl)	Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)	
21-30	Female	3	70	4866.67	47.5	43.33	2.67	0	5	45
31-40	Female	4	70.75	4775	48.25	34.4	2.5	0	6.25	68
41-50	Female	6	70.33	4800	48	42.83	2.67	0	5.67	64.67
51-60	Female	3	48	4200.00	41.00	44.67	2.67	0	7.33	112
Mean / Standard deviation			66.19±10.08	4693.75±329.58	46.65±3.17	43.31±2.06	2.62±0.62	0.00±0.00	5.94±2.11	70.69±28.65
Control	Female		69.25±7.72	4887.50±343.08	47±3.81	42.12±083	3.13±0.99	0.00±0.00	4.62±1.60	24.13±1.81
Normal range: FBC and ESR.	Female		12-16g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%	0-29 mm/hr.

4.1.2.7 Results of chest x-ray and sputum of male and female workers in the asphalt industry, Enugu.

Tables 4.1h (i) and 4.1h (ii) shows chest x-ray and sputum of male and female workers in the asphalt industry, Enugu. The average value of the cardiothoracic ratio recorded for the male workers was 0.40±0.08 cm, and that of the female workers was 0.35±0.06 cm. This ratio was correlated with the age of the workers, which is illustrated in Figure 4.1g. The correlation coefficient was 0.632455532 for the male and 0.894427191 for the female workers. The transverse cardiac diameter mean values of 15.33±0.13 cm and 14.35±0.06 cm were recorded for the male and female workers, respectively. The mediastinum in posterior-anterior view of the chest x-ray deviated as well as the trachea. The right atrium, the ascending aorta and superior vena cava were contained in the right contour of the mediastinum. The right ventricle partially overlaid the left ventricle. The left atrium was located inferior to the left pulmonary hilum. The left ventricle rounded apex of the heart, and great vessels were viewed as frontal projection. On the lateral view of the chest x-ray, the left pulmonary artery was seen coursing superiorly and posteriorly relative to the right side of the mediastinum while the left ventricle slopped inferiorly.

The workers' with normal chest x-ray: lung borders; thoracic spine, neck costophrenic angles, lung apices, retrocardiac space, and retrosternal space had no areas of opacities for infiltrates or masses. The workers' chest x-ray were marked by induration of a normally aerated lung which was considered a radiologic sign of consolidation. Consolidation of the lung affected an equal number 50(5%) each, of male and female between the age group 41-60 years, had a consolidation of the lung. The consolidation of the lung was correlated with the age of workers and is illustrated in Figure 4.1h. The correlation coefficient was 0.25819889 and 0.774596669 for the male and female workers, respectively. Besides, the radiologic markers of TB were seen in the chest x-ray film of a 55-year-old male tipper driver. The TB affected the pulmonary parenchyma, interstitium, pleural effusion and pericardium. There were marked opacities in the upper lobe of the lung, cavitations, unilateral pleural effusion and hilar lymphadenopathy with resultant coarse reticular opacities. The right lung borders; thoracic spine, costophrenic angles, lung apices, retrocardiac space, and retrosternal space had areas of opacities.

From the sputum sample (x 3) produced by that same worker, there were numerous (+++) rod-shaped bacilli seen per hundred (100) fields under the microscope after the staining procedure, and it showed a positive result to *Mycobacterium tuberculosis*. The sputum samples from the other workers were negative to *Mycobacterium tuberculosis.*

Table 4.1h (i): Chest x-ray and sputum of male workers in asphalt industry, Enugu

Age group (years)	Sex		Chest X-Ray												Sputum	
			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Male	2	0.4	15.2	0	2	0	2	0	2	0	2	0	2	0	2
31-40	Male	4	0.3	15.3	0	4	0	4	0	4	0	4	0	4	0	4
41-50	Male	3	0.4	15.3	0	3	0	3	0	3	0	3	0	3	0	3
51-60	Male	1	0.5	15.5	0	1	1	0	1	0	1	0	1	0	1	0
Mean			0.40	15.33	0.00	2.5	0.25	2	0.25	2.25	0.25	2.25	0.25	2.25	0.3	2.25
Standard deviation			0.08	0.13	0.00	1.29	0.50	1.71	0.50	1.71	0.50	1.71	0.50	1.71	0.43	1.71

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels,

LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, *AFB - Acid-fast bacilli.*

Table 4.1h (ii): Chest x-ray and sputum of female workers in asphalt industry, Enugu

Age group (years)	Sex		Chest X-Ray												Sputum	
			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Female	1	0.3	14.3	0	1	0	1	0	1	0	1	0	1	0	1
31-40	Female	4	0.3	14.3	0	4	0	4	0	4	0	4	0	4	0	4
41-50	Female	4	0.4	14.4	0	4	0	4	0	4	0	4	0	4	0	4
51-60	Female	1	0.4	14.4	0	1	1	0	0	1	0	1	0	1	0	1
Mean			0.35	14.35	0.00	2.5	0.25	2.25	0.00	2.5	0.00	2.5	0.00	2.5	0.0	2.5
Standard deviation			0.06	0.06	0.00	1.73	0.50	2.06	0.00	1.73	0.00	1.73	0.00	1.73	0.00	1.73

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels,

LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, *AFB - Acid-fast bacilli.*

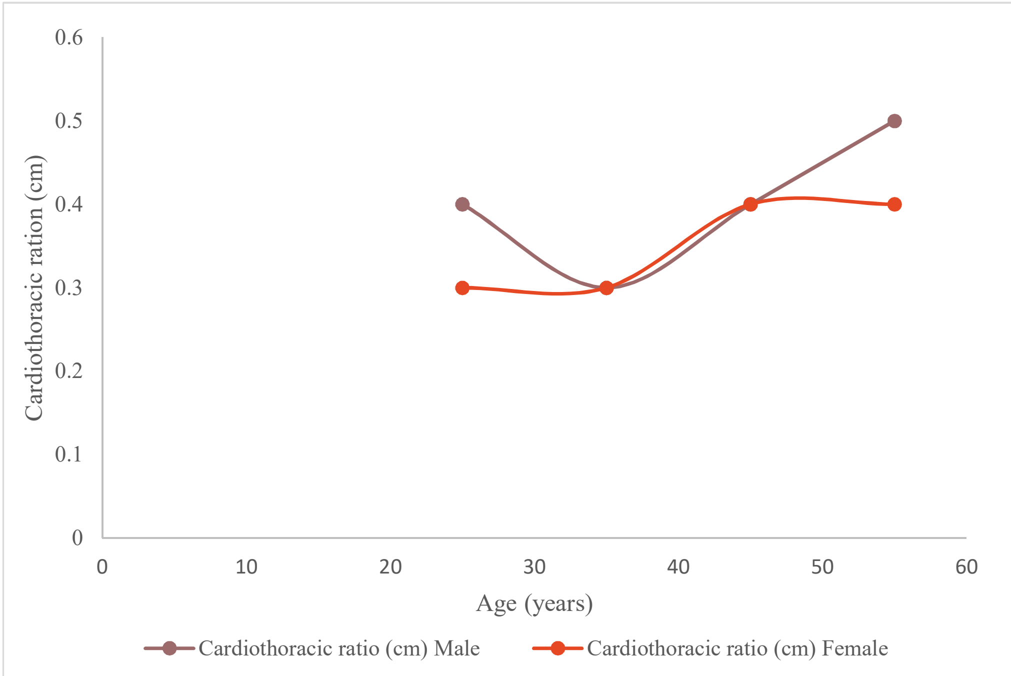

Figure 4.1g: Correlation of cardiothoracic ratio with the age of the workers in the asphalt industry.

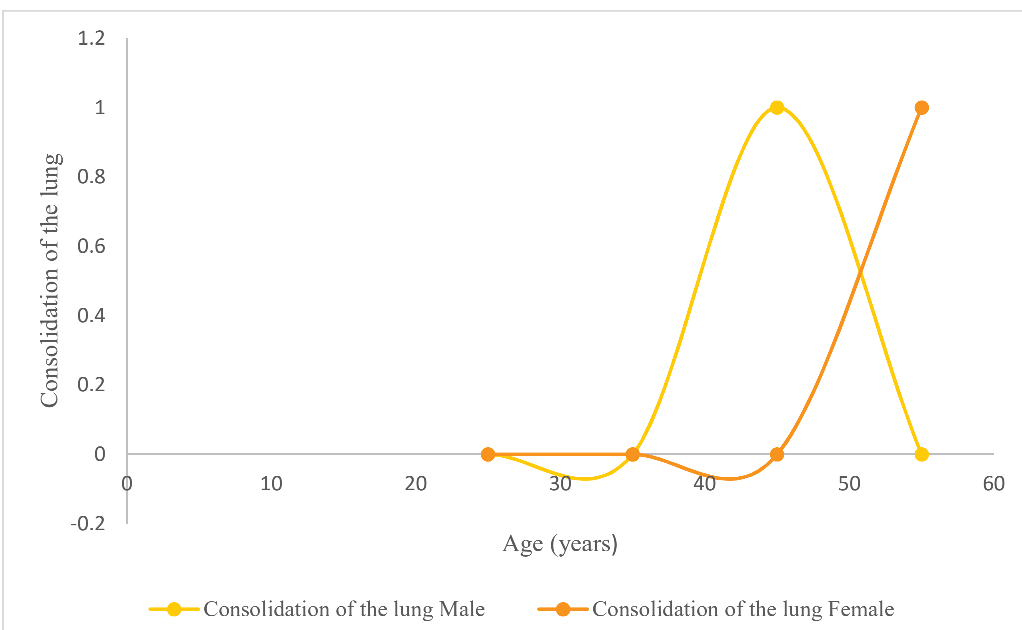

Figure 4.1h: Correlation of consolidation of the lung with the age of the workers in the asphalt industry.

4.1.2.8 Results of full blood count and erythrocyte sedimentation rate (ESR) of male and female workers in the asphalt industry, Enugu.

Table 4.1I (i) shows the full blood count and erythrocyte sedimentation rate (ESR) of male workers in the asphalt industry at Enugu. Male workers had an average value of 71.80±13.76% for haemoglobin. The mean values of white blood cells total count recorded 4750.00±190.03 mcl. For the direct count, the mean values were: neutrophil, 49.50±3.03%; lymphocytes, 43.40±1.51%; monocytes, 34.70±16.99%; basophils, 0.00±0.00%; and eosinophils, 5.10±2.69%. The average value of erythrocyte sedimentation rate for asphalt male workers was 34.90±16.85 mm/hr.

Table 4.1I (ii) shows the full blood count and erythrocyte sedimentation rate (ESR) of female workers in the asphalt industry at Enugu. Female workers had an average value of 55.90±13.00% for haemoglobin. The mean values of white blood cells total count recorded was 4467.50±276.90 mcl. For the direct count, the mean values were: neutrophil, 48.00±2.62%; lymphocyte, 42.87±1.61%; monocytes, 42.00±1.94%; basophils, 0.00±0.00%; and eosinophil, 7.29±2.58b %. The average value of erythrocyte sedimentation rate for asphalt female workers was 39.70±39.64 mm/hr.

Table 4.1I (ii): Full blood count and erythrocyte sedimentation rate (ESR) of female workers in asphalt industry, Enugu

Age group (years)	Sex	No.	Full Blood Count: Haemoglobin (g/dl)	White Bood Cell Total count (mcl)	Direct count: Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)	Erythrocyte Sedimentation Rate (mm/hr.)
21-30	Female	1	75.00	4675.00	53.00	41.75	42.00	0.00	3.50	15.00
31-40	Female	4	66.00	4700.00	48.00	44.00	43.50	0.00	6.00	36.00
41-50	Female	4	44.00	4200.00	47.00	42.00	41.00	0.00	10.00	22.00
51-60	Female	1	44.00	4400.00	47.00	43.00	40.00	0.00	5.40	150.00
Mean / Standard deviation			55.90±13.00	4467.50±276.90	48.00±2.62	42.87±1.61	42.00±1.94	0.00±0.00	7.29±2.58	39.70±39.64
Control	Female		69.25±7.72	4887.50±343.08	47±3.81	42.12±083	3.13±0.99	0.00±0.00	4.62±1.60	24.13±1.81
Normal range: FBC and ESR.			Female: 12-16g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%	0-29 mm/hr.

Table 4.1I (i): Full blood count and erythrocyte sedimentation rate (ESR) of male workers in asphalt industry, Enugu

Age group	Sex	No.	Full Blood Count							Erythrocyte Sedimentation Rate (mm/hr.)
(years)			Haemoglobin	White Bood Cell						
			(g/dl)	Total count	Direct count					
				(mcl)	Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)	
21-30	Male	2	88.50	4700.00	52.00	42.50	2.50	0.00	3.50	17.50
31-40	Male	4	67.60	4675.00	48.50	43.25	43.50	0.00	4.60	33.75
41-50	Male	3	64.33	4833.33	49.00	44.00	42.00	0.00	6.00	51.00
51-60	Male	1	68.00	4900.00	50.00	44.00	42.00	0.00	6.00	26.00
Mean / Standard deviation			71.80±13.76	4750.00±190.03	49.50±3.03	43.40±1.51	34.70±16.99	0.00±0.00	5.10±2.69	34.90±16.85
Control	Males		76.43±6.65	5485.71±61	49.57±1.72	39.29±6.40	2.14±1.57	0.00±0.00	4.86±0.00	22.14±1.86
Normal range: FBC and ESR.			Male: 14-18g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%	0-22 mm/hr.

4.1.2.9 Results of chest x-ray and sputum of male and female workers in brewery industry, Awo-omamma.

Table 4.1j (i) and 4.1j (ii) shows the results of chest x-ray and sputum of male and female workers in brewery industry at Awo-omamma. The average value of the cardiothoracic ratio recorded for the male workers was 0.35±0.0 6cm, and that of the female workers was 0.33±0.05 cm. This ratio was correlated with the age of the workers, which is illustrated in figure 4.1i. The correlation coefficient was 0.894427191 for the male and 0.774596669 for the female workers. The transverse cardiac diameter mean values of 15.28±0.04 cm and 14.25±0.09 cm were recorded for the `male and female workers, respectively. The mediastinum in posterior-anterior view of the chest x-ray had a centrally located position, as well as the trachea. The right atrium, the ascending aorta and superior vena cava were contained in the right contour of the mediastinum. The right ventricle partially overlaid the left ventricle. The left atrium was located inferior to the left pulmonary hilum. The left ventricle prominently rounded apex of the heart and great vessels were viewed as frontal projection.

The lateral view of the chest x-ray, the left pulmonary artery was seen coursing superiorly and posteriorly relative to the right side of the mediastinum while the left ventricle slopped inferiorly. There was no evidence of mitral stenosis, chronic obstructive pulmonary disease, atelectasis or lung parenchyma involvement with fine or coarse reticular opacities or small nodules. The workers' with normal chest x-ray: lung borders; thoracic spine, neck costophrenic angles, lung apices, retrocardiac space, and retrosternal space had no areas of opacities for infiltrates or masses while some of the workers' chest x-ray were marked by induration of a normally aerated lung which was considered a radiologic sign of consolidation. Consolidation of the lung affected 105 (11%) of the female workers who were within the age group 51-60 years while the male workers were typical. The consolidation of the lung was correlated with the age of workers and is illustrated in Figure 4.1j. The correlation coefficient was 0.894427191 for female workers. From the sputum samples (x3), there were no rod-shaped bacteria (bacilli) seen per hundred (100) fields under the microscope after the staining procedure. The *acid-fast bacilli* were negative for the workers that participated in the screening test carried out in the brewery industry.

Table 4.1j(i): Chest x-ray and sputum of male workers in brewery industry, Awo-omamma

Age group (years)	Sex	No.	Chest X-Ray												Sputum	
			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Male	2	0.3	15.2	0	2	0	2	0	2	0	2	0	2	0	2
31-40	Male	2	0.3	15.3	0	2	0	2	0	2	0	2	0	2	0	2
41-50	Male	3	0.4	15.3	0	3	0	3	0	3	0	3	0	3	0	3
51-60	Male	1	0.4	15.3	0	1	0	1	0	1	0	1	0	1	0	1
Mean			0.35	15.28	0.00	2.00	0.00	2.00	0.00	2.00	0.00	2.00	0.00	2.00	0.00	2.00
Standard deviation			0.06	0.05	0.00	0.82	0.00	0.82	0.00	0.82	0.00	0.82	0.00	0.82	0.00	0.82

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels,

LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, *AFB - Acid-fast bacilli.*

Table 4.1j(ii): Chest x-ray and sputum of female workers in brewery industry, Awo-omamma

Age group (years)	Sex	No.	Chest X-Ray												Sputum	
			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Female	1	0.3	14.2	0	1	0	1	0	1	0	1	0	1	0	1
31-40	Female	4	0.3	14.2	0	4	0	4	0	4	0	4	0	4	0	4
41-50	Female	3	0.3	14.2	0	3	1	2	0	3	0	3	0	3	0	3
51-60	Female	3	0.4	14.4	0	3	1	2	0	3	0	3	0	3	0	3
Mean			0.33	14.25	0.00	2.75	0.50	2.25	0.00	2.75	0.00	2.75	0.00	2.75	0.00	2.75
Standard deviation			0.05	0.10	0.00	1.26	0.58	1.26	0.00	1.26	0.00	1.26	0.00	1.26	0.00	1.26

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels,
LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, *AFB - Acid-fast bacilli.*

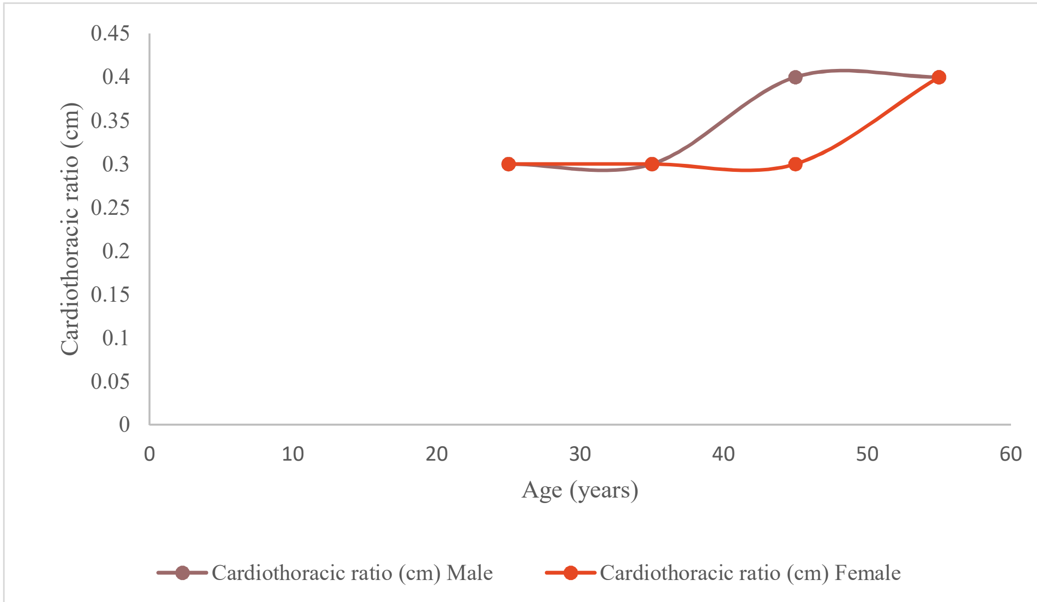

Figure 4.1i: Correlation of cardiothoracic ratio with the age of the workers in the brewery industry.

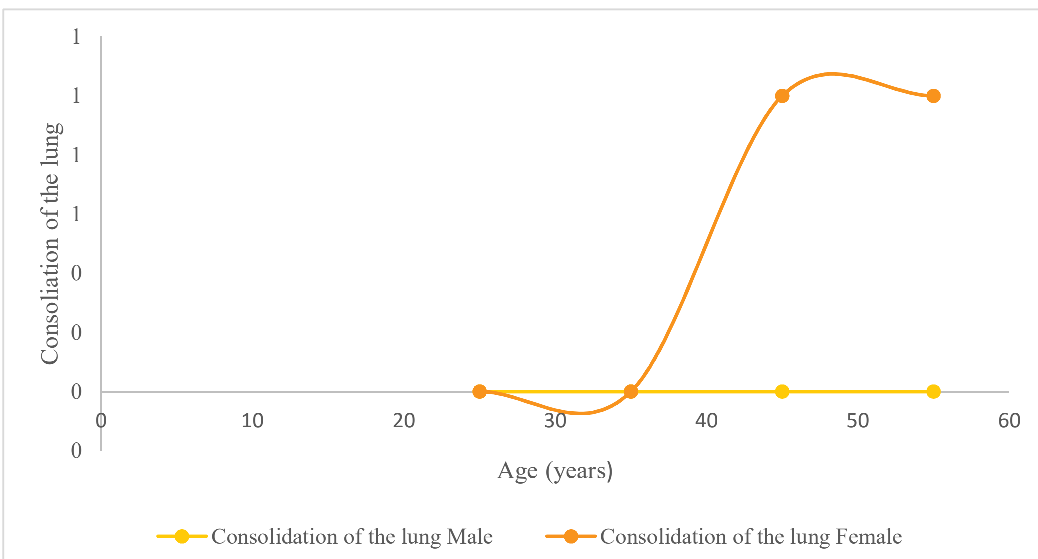

Figure 4.1j: Correlation of consolidation of the lung with the age of the workers in the brewery industry.

4.1.2.10 Results of full blood count and erythrocyte sedimentation rate (ESR) of male and female workers in brewery industry at Awo-omamma.

Table 4.1k (i) shows the results of full blood count and erythrocyte sedimentation rate (ESR) of male workers in brewery industry at Awo-omamma. Male workers had an average value of 78.00±5.53% for haemoglobin. The mean values of white blood cells total count recorded was 4985.65±200.55 mcl. For the direct count, neutrophil was 49.13±1.25%; lymphocyte, 42.38±0.92%; monocytes, 3.50±1.06%; basophils, 0.00±0.00%; and eosinophil, 5.00±1.77%. The average value of erythrocyte sedimentation rate for brewery male workers was 36.00±33.43 mm/hr.

Table 4.1k (ii) shows the full blood count and erythrocyte sedimentation rate (ESR) of female workers in Brewery industry at Awo-omamma. Female workers had an average value of 64.45±9.53% for haemoglobin. The mean values of white blood cells total count recorded was 4772.7300±283.16 mcl. For the direct count, the mean values were, neutrophil, 48.36±2.33%; lymphocyte, 43.00±0.89%; monocytes, 3.18±0.60%; basophils, 0.00±0.00%; and eosinophil, 6.00±2.23%. The average value of erythrocyte sedimentation rate for female brewery workers was 46.82±27.45 mm/hr.

Table 4.1k (i): Full blood count and erythrocyte sedimentation rate (ESR) of male workers in brewery industry , Awo-omamma

Age group (years)	Sex	No.	Full Blood Count							Erythrocyte Sedimentation Rate (mm/hr.)
			Haemoglobin (g/dl)	White Blood Cell						
				Total count (mcl)	Direct count					
					Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)	
	Male	2	84.00	5050.00	50.00	41.50	4.50	0.00	4.00	7.50
31-40	Male	2	71.00	5040.00	47.50	42.00	3.00	0.00	7.50	56.50
41-50	Male	3	79.00	4866.67	50.00	42.67	3.33	0.00	4.00	46.67
51-60	Male	1	77.00	5100.00	48.00	44.00	3.00	0.00	5.00	20.00
Mean / Standard deviation			78.00±5.53	4985.65±200.55	49.13±1.25	42.38±0.92	3.50±1.06	0.00±0.00	5.00±1.77	36.00±33.43
Control	Males		76.43±6.65	5485.71±61	49.57±1.72	39.29±6.40	2.14±1.57	0.00±0.00	4.86±0.00	22.14±1.86
Normal range: FBC and ESR.			Male: 14-18g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%	0-22 (mm/hr.)

Table 4.1k(ii): Full blood count and erythrocyte sedimentation rate (ESR) of female workers in brewery industry, Awo-omamma

Age group (years)	Sex	No.	Full Blood Count							Erythrocyte Sedimentation Rate (mm/hr.)
			Haemoglobin (g/dl)	White Blood Cell						
				Total count (mcl)	Direct count					
					Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)	
21-30	Female	1	40.00	5100.00	44.00	42.00	4.00	0.00	10.00	120.00
31-40	Female	4	62.50	4500.00	49.00	43.00	2.80	0.00	5.00	43.75
41-50	Female	3	73.00	4966.67	50.00	44.00	2.67	0.00	4.67	33.33
51-60	Female	3	66.67	4833.33	47.33	42.33	3.00	0.00	7.33	40.00
Mean / Standard deviation			64.45±9.53	4772.7300±283.16	48.36±2.33	43.00±0.89	3.18±0.60	0.00±0.00	6.00±2.23	46.82±27.45
Control	Female		69.25±7.72	4887.50±343.08	47±3.81	42.12±083	3.13±0.99	0.00±0.00	4.62±1.60	24.13±1.81
Normal range: FBC and ESR.			Female: 12-16g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%	0-29 (mm/hr.)

4.1.2.11 Results of chest x-ray and sputum of male and female workers in selected industries, South-Eastern Nigeria.

Table 4.1l (i) and 4.1l (ii) shows results of chest x-ray and sputum of male and female workers, respectively, in selected industries in South-Eastern Nigeria. The various mean values of the cardiothoracic ratio for male workers in the industries studied were as follows: healthcare workers, 0.40±0.07 cm; quarry workers, 0.35±0.05 cm; road construction workers, 0.45±0.05 cm; asphalt workers, 0.40±0.07 cm and 0.35±0.05 cm for brewery workers. The cardiothoracic ratio for male control subject recorded was 0.35±0.05 cm. The various mean values of the cardiothoracic ratio for the female workers in the industries studied were as follows: healthcare workers, 0.33±0.04 cm; quarry workers, 0.40±0.07 cm; road construction workers, 0.35±0.05 cm; asphalt workers, 0.33±0.04 cm and 0.35±0.05 cm for brewery workers. The cardiothoracic ratio for female control subject recorded was, 0.35±0.05 cm was recorded for the female control subject. The average of the various parameters investigated was compared. The cardiothoracic ratio and consolidation of the lung of both male and female workers in selected industries are illustrated in Figures 4.1k and 4.1l, respectively.

The transverse cardiac diameter for the industries studied for both male and female are illustrated in Figures 4.1m (i) and 4.1m (ii), respectively. The mean values for the male workers in healthcare were 15.38±0.10 cm; quarry, 15.35±0.13 cm; road construction, 15.30±0.08 cm; asphalt, 15.33±0.13 cm; brewery, 15.28±0.05 cm. The mean values of the transverse cardiac diameter, 15.28±0.05 cm was for the male control subjects. The mean values of the transverse diameter for the female workers in industries are; healthcare, 14.30±0.10 cm; quarry, 14.25±0.09 cm; road construction, 14.25±0.09 cm; asphalt, 14.35±0.05 cm and brewery, 14.25±0.09 cm. The female control subjects had a mean value of 14.23±0.05 cm. There was no evidence of mitral stenosis, chronic obstructive pulmonary disease, atelectasis or small nodules in lung parenchyma for the workers in the industries studied, except for the involvement of pulmonary tuberculosis in the asphalt industry. Chest radiology showed that some workers were affected with consolidation of the lung.

Incidence, of consolidation of the lung among males /females workers aged 21-60 were: 71 (7%) of healthcare workers had consolidation of the lung, 2% were males, while 5% were females; quarry workers, 130 (13%) out of which 9% were males while 4% were females; road construction workers, had 290 (29%) infected with consolidation of the lung; 16% were males, while 13% were females. In asphalt industry consolidation of the lung affected 100 (10%) of the workers 5% each of both male and female, while in the brewery industry only the female workers, 105 (11%) were infected with the consolidation of the lung. The consolidation of the lung was correlated with the age of workers in the selected industries and is illustrated in Figure 4.1k.

The sputum test for *acid-fast bacilli* showed negative results in healthcare, quarry, road construction, and brewery industries while the only positive (+++) *Mycobacterium tuberculosis* sputum result was recorded from a male worker in the asphalt industry.

Table 4.11 (i): Chest x-ray and sputum of male workers in selected industries, South-Eastern Nigeria

Age range	Workers	Industries	Chest X-Ray												Sputum	
(years)			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-60	14	Healthcare	0.40±0.08	15.38±1.13	0.00±0.00	3.50±3.70	0.25±0.50	3.25±3.20	0.00±0.00	3.50±3.70	0.00±0.00	3.50±3.70	0.00±0.00	3.50±3.70	0.00±0.00	3.50±3.70
21-60	11	Quarry	0.35±0.06	15.35±0.13	0.00±0.00	2.75±1.26	0.50±0.58	2.25±0.96	0.00±0.00	2.75±1.26	0.00±0.00	2.75±1.26	0.00±0.00	2.75±1.26	0.00±0.00	2.75±1.26
21-60	15	Road construction	0.45±0.06	15.30±0.08	0.00±0.00	3.75±2.06	1.25±0.50	2.50±1.91	0.00±0.00	3.75±2.06	0.00±0.00	3.75±2.06	0.00±0.00	3.75±2.06	0.00±0.00	3.75±2.06
21-60	10	Asphalt	0.40±0.08	15.33±0.13	0.00±0.00	2.50±1.29	0.25±0.50	2.25±1.71	0.25±0.50	2.25±1.71	0.25±0.50	2.25±1.71	0.25±0.50	2.25±1.71	0.25±0.50	2.25±1.71
21-60	8	Brewery	0.35±0.06	15.28±0.05	0.00±0.00	2.00±0.81	0.00±0.00	2.00±0.81	0.00±0.00	2.00±0.81	0.00±0.00	2.00±0.81	0.00±0.00	2.00±0.81	0.00±0.00	2.00±0.81
21-60	7	Control	0.35±0.06	15.28±0.05	0.00±0.00	1.75±0.50	0.00±0.00	1.75±0.50	0.00±0.00	1.75±0.50	0.00±0.00	1.75±0.50	0.00±0.00	1.75±0.50	0.00±0.00	1.75±0.50

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels, LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, AFB - *Acid-fast bacilli.*

Table 4.11 (ii): Chest x-ray and sputum of female workers in selected industries in South-Eastern Nigeria

Age range	Workers	Industries	Chest X-Ray												Sputum	
(years)			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-60	28	Healthcare	0.35±0.06	14.30±0.12	0.00±0.00	7.00±4.69	0.50±0.58	6.50±4.12	0.00±0.00	7.00±4.69	0.00±0.00	7.00±4.69	0.00±0.00	7.00±4.69	0.00±0.00	7.00±4.69
21-60	12	Quarry	0.33±0.05	14.25±0.10	0.00±0.00	3.00±1.41	0.25±0.50	2.75±1.26	0.00±0.00	3.00±1.41	0.00±0.00	3.00±1.41	0.00±0.00	3.00±1.41	0.00±0.00	3.00±1.41
21-60	16	Road construction	0.40±0.08	14.25±0.10	0.00±0.00	4.00±1.41	1±0.82	3.00±1.41	0.00±0.00	4.00±1.41	0.00±0.00	4.00±1.41	0.00±0.00	4.00±1.41	0.00±0.00	4.00±1.41
21-60	10	Asphalt	0.35±0.06	14.35±0.06	0.00±0.00	2.50±1.73	0.25±0.50	2.25±2.06	0.00±0.00	2.50±1.73	0.00±0.00	2.50±1.73	0.00±0.00	2.50±1.73	0.00±0.00	2.50±1.73
21-60	11	Brewery	0.33±0.05	14.25±0.10	0.00±0.00	2.75±1.26	0.50±0.60	2.25±1.26	0.00±0.00	2.75±1.09	0.00±0.00	2.75±1.26	0.00±0.00	2.75±1.26	0.00±0.00	2.75±1.26
21-60	8	Control	0.35±0.06	14.23±0.05	0.00±0.00	1.5±0.60	0.00±0.00	1.5±0.60	0.00±0.00	1.5±0.60	0.00±0.00	1.5±0.60	0.00±0.00	1.5±0.60	0.00±0.00	1.5±0.60

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels, LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, AFB - Acid-fast bacilli.

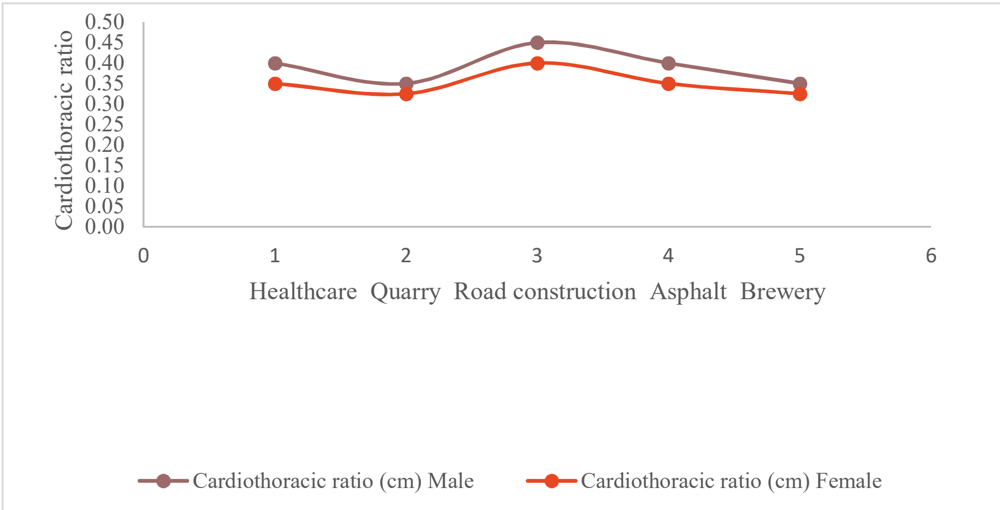

Figure 4.1k: Correlation of cardiothoracic ratio of the workers in the selected industries.

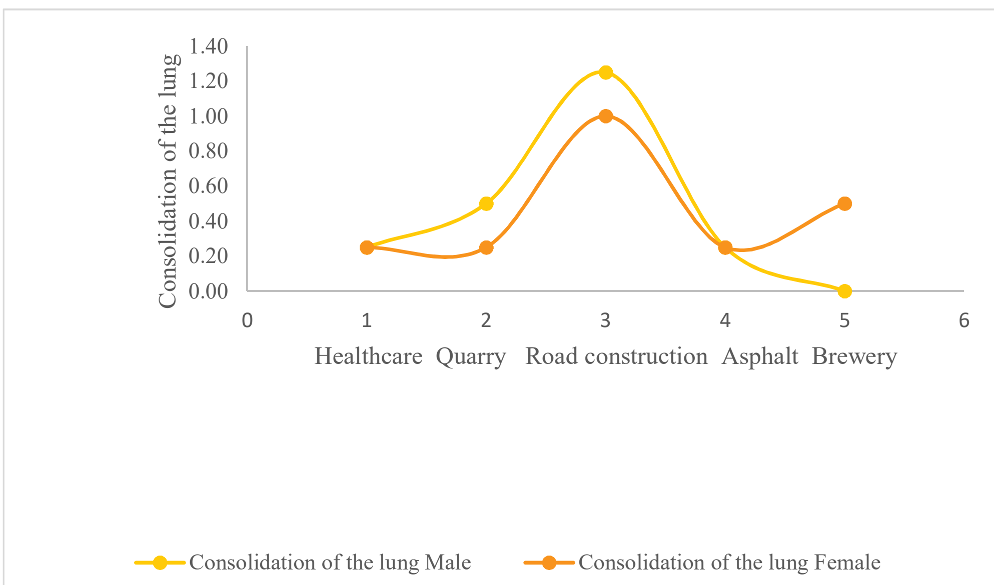

Figure 4.1l: Correlation of consolidation of the lung of workers in the selected industries.

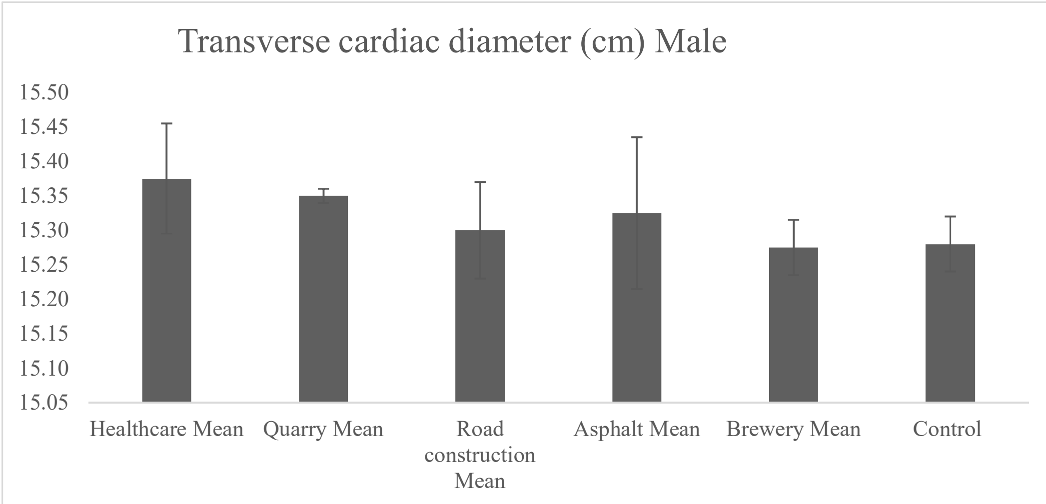

Figure 4.1m (i): Transverse cardiac diameter of the male workers in the selected industries.

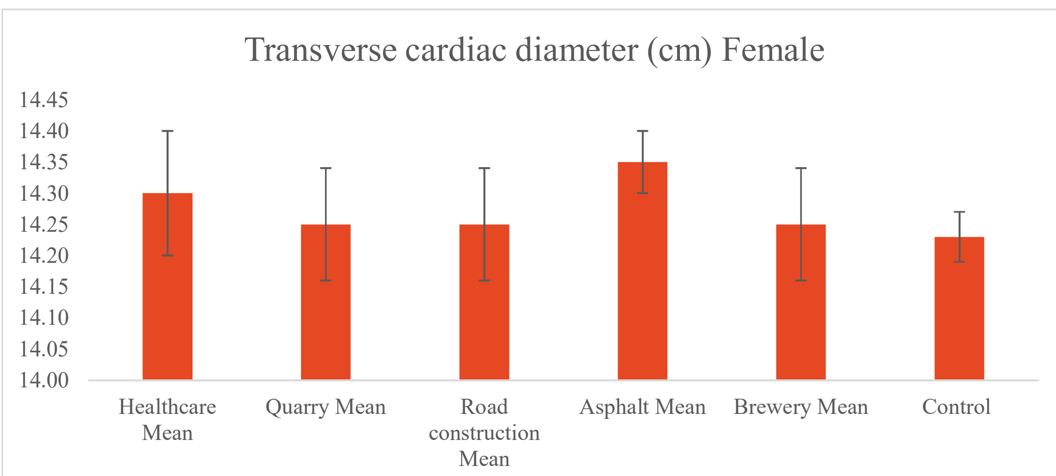

Figure 4.1m (ii): Transverse cardiac diameter of the female workers in the selected industries.

4.1.2.12 Results of full blood count and erythrocyte sedimentation rate (ESR) of workers in selected industries in South-Eastern Nigeria.

4.1.2.12.1 Results of full blood count and erythrocyte sedimentation rate (ESR) of male workers.

Table 4.1m (i) shows the mean values of full blood count and erythrocyte sedimentation rate (ESR) of male workers in selected industries in South-Eastern Nigeria. The mean values (78.00±5.53%^{b}) of haemoglobin among male workers in the brewery industry was not significantly different (p>0.05) from the control (76.43±6.65%^{b}). The other industries with haemoglobin mean values, among healthcare (67.56±2.98%^{a}); quarry (71.45±9.03%^{a,b}); road construction (71.00±9.99%^{a,b}); and asphalt (71.80±13.76%^{a}) workers, were significantly different (p<0.05) from the control. For white blood cell total count, the mean values were, 5742.86±814.03 mcl^{c} and 5272.72±473.48 mcl^{b,c} for the healthcare and quarry workers, respectively, and the mean values were not significantly different (p>0.05) from the control. The mean values among the male workers in road construction (4915.47±416.44 mcl^{a,b}); asphalt (4750.00±190.03 mcl^{a}) and brewery (4985.65±200.55 mcl^{a,b}) were significantly different (p<0.05) from the control (5485.71±61 mcl^{c}). For white blood cell direct count, the mean values of neutrophisl and eosinophils in all the industries were not significantly different (p>0.05) from their control. The mean values of lymphocyte in healthcare (42.50±2.77%^{b}); quarry (42.55±1.51%^{b}); road construction (42.80±1.27%^{b}); asphalt (43.40±1.51%^{b}) and brewery (42.38±0.92%^{b}) industries, were significantly different (p<0.05) from the control. The mean values of basophil in the industries studied were not significantly different (p>0.05) from the control (NS) except in road construction with mean value

(2.67±3.97%^{b}) was significantly different (p<0.05) from the control.

The mean values of monocytes among healthcare (3.07±0.83%[a]); quarry (2.63±0.67%[a]); road construction (2.87±1.19%[a]) and brewery (3.50±1.06%[a]) male workers, were not significantly different ($p>0.05$) from the control while the mean value (34.70±16.99%[b]) among asphalt male workers was significantly different ($p<0.05$) from the control (2.14±1.57%[a]). For ESR the mean values among healthcare (54.50±8.30 mm/hr.[b,c]); road construction (53.67±23.18 mm/hr.[b,c]); asphalt (34.90±16.85 mm/hr.[a]) and brewery (36.00±33.43 mm/hr.[a]) male workers were not significantly different ($p>0.05$) from the control while the mean value of ESR among quarry male workers was (71.45±20.97 mm/hr.[c]) and was significantly different ($p<0.05$) from the control (22.25±1.09 mm/hr.[a,b]).

Table 4.1m (i): Full Blood count and erythrocyte sedimentation rate (ESR) of male workers in selected industries in South-Eastern Nigeria

Age range (years)	Workers	Industries	Full Blood Count							Erythrocyte Sedimentation Rate (mm/hr.)
			Haemoglobin (g/dl)	White Blood Cell						
				Total count (mcl)	Direct count					
					Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)	
21-60	14	Healthcare Males	67.56 ± 2.98^{a}	5742.86 ± 814.03^{c}	48.64 ± 2.68^{a}	42.50 ± 2.77^{b}	3.07 ± 0.83^{a}	0.00 ± 0.00^{a}	5.42 ± 2.71^{a}	$54.50 \pm 8.30^{b,c}$
21-60	11	Quarry Males	$71.45 \pm 9.03^{a,b}$	$5272.72 \pm 473.48^{b,c}$	48.00 ± 2.37^{a}	42.55 ± 1.51^{b}	2.63 ± 0.67^{a}	0.00 ± 0.00^{a}	6.81 ± 2.40^{a}	71.45 ± 20.97^{c}
21-60	15	Road construction Males	$71.00 \pm 9.99^{a,b}$	$4915.47 \pm 416.44^{a,b}$	49.40 ± 3.04^{a}	42.80 ± 1.27^{b}	2.87 ± 1.19^{a}	2.67 ± 3.97^{b}	4.93 ± 2.40^{a}	$53.67 \pm 23.18^{b,c}$
21-60	10	Asphalt males	$71.80 \pm 13.76^{a,b}$	4750.00 ± 190.03^{a}	49.50 ± 3.03^{a}	43.40 ± 1.51^{b}	34.70 ± 16.99^{b}	0.00 ± 0.00^{a}	5.10 ± 2.69^{a}	34.90 ± 16.85^{a}
21-60	8	Brewery Males	78.00 ± 5.53^{b}	$4985.65 \pm 200.55^{a,b}$	49.13 ± 1.25^{a}	42.38 ± 0.92^{b}	3.50 ± 1.06^{a}	0.00 ± 0.00^{a}	5.00 ± 1.77^{a}	36.00 ± 33.43^{a}
21-60	7	Control Males	76.43 ± 6.65^{b}	5485.71 ± 595.62^{c}	49.57 ± 1.72^{a}	39.29 ± 6.40^{a}	2.14 ± 1.57^{a}	0.00 ± 0.00^{a}	4.86 ± 2.19^{a}	$22.25 \pm 1.09^{a,b}$
		Normal range Male: FBC and ESR.	14-18g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%	0-22 mm/hr.

Values with the same superscript across columns are not significantly different ($p>0.05$)

4.1.2.12.2 Results of full blood count and erythrocyte sedimentation rate (ESR) of female workers.

Table 4.1m (ii) shows the mean values of full blood count and erythrocyte sedimentation rate (ESR) of female workers in selected industries in South-Eastern Nigeria. The mean values of haemoglobin among healthcare (64.06±2.46%^{b}); quarry (66.00±12.74%^{b}); road construction (66.19±10.08%^{b}) and brewery (64.45±9.53%^{b}) female workers were not significantly different (p>0.05) from the control. The average value (57.25±13.63%^{a}) of haemoglobin among asphalt female workers was significantly different (p<0.05) from the control (69.25±7.72%^{b}). For white blood cell total count, the mean values among the female workers in the quarry (4900.00±575.26 mcl^{b}); road construction (4693.75±329.58 mcl^{a,b}) and brewery (4772.7300±283.16 mcl^{a,b}) female workers, were not significantly different (p>0.05) with the control. The average values of white blood cell total count among the female workers in healthcare (5825.00±545.89 mcl^{c}) and asphalt (4467.50±276.90 mcl^{a}) was significantly different (p<0.05) from the control. For the mean values of white blood cell direct count neutrophil, lymphocyte, basophil and eosinophil in all the industries, were not significantly different (p>0.05) from the control. The mean values of monocytes, among healthcare (2.87±062%^{a}); quarry (2.58±0.99%^{a}); road construction (2.62±0.62%^{a}) and brewery (3.12±0.52%^{a}) female workers were not significantly different (p>0.05) from the control, while the average value of monocytes among asphalt female workers (42.00±1.94%^{b}) was significantly different (p<0.05) from the control (3.13±0.99%^{a}). For the erythrocyte sedimentation rate of female workers, the mean values in healthcare, 62.63±30.19 mm/hr.^{b,c}); quarry (55.75±30.62 mm/hr.^{b,c}); road construction (70.69±28.65 mm/hr.^{c}); asphalt (39.70±39.64 mm/hr.^{a,b}) and brewery (46.82±27.45 mm/hr.^{a,b,c}) industries, were significantly different (p<0.05) from the control (24.67±1.58 mm/hr.^{a}).

Table 4.1m (ii): Full Blood count and erythrocyte sedimentation rate (ESR) of female workers in selected industries

Age range (years)	Workers	Industries	Full Blood Count							Erythrocyte Sedimentation Rate (mm/hr.)
			Haemoglobin (g/dl)	White Blood Cell						
				Total count	Direct count					
				(mcl)	Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Basophil (%)	Eosinophil (%)	
21-60	16	Healthcare Females	$64.06±2.46^{b}$	$5825.00±545.89^{c}$	$48.25±3.92^{a}$	$42.87±1.41^{a}$	$2.87±062^{a}$	$0.25±0.77^{a}$	$6.00±3.14^{a,b}$	$62.63±30.19^{b,c}$
21-60	12	Quarry Females	$66.00±12.74^{b}$	$4900.00±575.26^{b}$	$433±2.93^{a}$	$42.58±1.68^{a}$	$2.58±0.99^{a}$	$0.00±0.00^{a}$	$5.91±2.50^{a,b}$	$55.75±30.62^{b,c}$
21-60	16	Road construction Females	$66.19±10.08^{b}$	$4693.75±329.58^{a,b}$	$46.65±3.17^{a}$	$43.31±2.06^{a}$	$2.62±0.62^{a}$	$0.00±0.00^{a}$	$5.94±2.11^{a,b}$	$70.69±28.65^{c}$
21-60	10	Asphalt Females	$55.90±13.00^{a}$	$4467.50±276.90^{a}$	$48.00±2.62^{a}$	$42.87±1.61^{a}$	$42.00±1.94^{b}$	$0.00±0.00^{a}$	$7.29±2.58^{b}$	$39.70±39.64^{a,b}$
21-60	11	Brewery Females	$64.45±9.53^{b}$	$4772.7300±283.16^{a,b}$	$48.36±2.33^{a}$	$43.00±0.89_{a}$	$3.18±0.60^{a}$	$0.00±0.00^{a}$	$6.00±2.23^{a,b}$	$46.82±27.45^{a,b,c}$
21-60	8	Control Females	$69.25±7.72^{b}$	$4887.50±343.08^{b}$	$47±3.81^{a}$	$42.12±0.83^{a}$	$3.13±0.99^{a}$	$0.00±0.00^{a}$	$4.62±1.60^{a}$	$24.13±1.81^{a}$
		Normal range Females: FBC and ESR.	12-16g/dl	4,500-10,000mcl	40–80%	20–40%	2–10%	< 1–2%	1–6%	0-29 mm/hr.

Values with the same superscript across columns are not significantly different (P>0.05)

4.1.2.13 Results of heavy metal analysis on the hair of workers

As shown in Table 4.1n, the mean values of some heavy metals on the hair of workers in the selected industries in South-Eastern Nigeria, varied. The mean values of lead among healthcare industry (0.01±0.01 mg/l[a]) was not significantly different ($p>0.05$) from the controls while the mean values in quarry (0.26±0.04 mg/l[e]); road construction (0.21±0.10 mg/l[d,e]); asphalt (0.07±0.07 mg/l[a,b]) and brewery (0.05±0.02 mg/l[a,b]) industries were significantly different ($p<0.05$) from their controls. The peak values of lead (0.26±0.03 mg/l) was recorded among quarry workers, but least (0.01±0.01 mg/l) among workers in the healthcare industry, Owerri. The mean values of cadmium among workers in quarry (0.12±0.01 mg/l[a]); road construction (0.09±0.01 mg/l[a]); asphalt (0.26±0.06 mg/l[a]) and brewery (0.05±0.02 mg/l[a]) industries were not significantly different ($p>0.05$) from their controls while the mean value (0.79±0.03 mg/l[b]) of cadmium among workers in the healthcare industry was significantly different ($p<0.05$) from the control. The peak value of cadmium (0.79±0.03 mg/l) was recorded among workers in the healthcare industry and the least value (0.05±0.02 mg/l) among brewery workers.

The mean values of mercury among workers in healthcare (0.02±0.01 mg/l[a]); quarry (0.01±0.10 mg/l[a]); road construction (0.11±0.03 mg/l[a]) and asphalt (0.08±0.09 mg/l[a]) were not significantly different ($p>0.05$) from their controls. The mean value of mercury (0.20±0.10 mg/l[b]) among workers in the brewery was, significantly different ($p<0.05$) from the control. The peak value of mercury was recorded in the brewery (0.20±0.10 mg/l) but least (0.01±0.10 mg/l) in the quarry industry. Arsenic mean values in healthcare (0.10±0.08 mg/l[b]); quarry (0.02±0.01 mg/l[a]); road construction (0.20±0.01 mg/l[a]) and asphalt (0.02±0.00 mg/l[a]) industries, were not significantly different ($p>0.05$) from their controls. The mean value of arsenic (0.02±0.00 mg/l[c]) among workers in the brewery was, significantly different ($p<0.05$) with the control (0.20±0.08 mg/la [a]). The level of arsenic in all the industries studied was within FMEnv Standard (1991).The mean value (0.02±0.02 mg/l[a]) of chromium among healthcare workers, was not significantly different ($p>0.05$) with the control (0.00±0.00 mg/l[a]) while the mean values of chromium among workers in quarry (0.11±0.06 mg/l[b]); road construction (0.12±0.01 mg/l[b]); asphalt (0.11±0.08 mg/l[b]) and brewery (0.10±0.08 mg/l[b,c]) industries, were significantly different ($P<0.05$) from their controls. Chromium was highest (0.12±0.01 mg/l) among road construction workers and least (0.02±0.02 mg/l) among healthcare workers.

Table 4.1n: Heavy metal analysis on human hair in some industries in South-Eastern Nigeria

Parameters	Healthcare		Quarry		Road construction		Asphalt		Brewery		FMEnv Standard (1991)
	Average	Control	Average	Control	Average	Control	Average	Control	Average	Control	
Lead (mg/l)	$0.01±0.01^{a}$	$0.01±0.01^{a}$	$0.26±0.04^{e}$	$0.17±0.01^{c,d}$	$0.21±0.10^{d,e}$	$0.01±0.01^{a}$	$0.07±0.07^{a,b}$	$0.05±0.01^{b,c}$	$0.05±0.02^{a,b}$	$0.01±0.01^{a}$	0.05
Cadmium (mg/l)	$0.79±0.03^{b}$	$0.06±0.02^{a}$	$0.12±0.01^{a}$	$0.05±0.01^{a}$	$0.09±0.01^{a}$	$0.05±0.03^{a}$	$0.26±0.06^{a}$	$0.02±0.08^{a}$	$0.05±0.02^{a}$	$0.05±0.02^{a}$	0.01
Mercury (mg/l)	$0.02±0.01^{a}$	$0.01±0.01^{a}$	$0.01±0.10^{a}$	$0.01±0.10^{a}$	$0.11±0.04^{a}$	$0.08±0.02^{a}$	$0.08±0.05^{a}$	$0.01±0.01^{a}$	$0.20±0.10^{b}$	$0.10±0.10^{a}$	0.00
Arsenic (mg/l)	$0.10±0.10^{b}$	$0.07±0.01^{a,b}$	$0.02±0.02^{a}$	$0.01±0.01^{a}$	$0.20±0.01^{a}$	$0.12±0.01^{a}$	$0.02±0.01^{a}$	$0.01±0.01^{b}$	$0.02±0.00^{c}$	$0.20±0.08^{a}$	0.20
Chromiuim (mg/l)	$0.02±0.02^{a}$	$0.01±0.00^{a}$	$0.11±0.07^{b}$	$0.01±0.01^{a}$	$0.12±0.01^{b}$	$0.01±0.01^{a}$	$0.11±0.08^{b}$	$0.01±0.00^{a}$	$0.10±0.10^{b,c}$	$0.01±0.00^{a}$	0.10

*Values with the same superscript across rows are not significantly different ($p>0.05$)

4.1.3 Control Subjects

4.1.3.1 Results of chest x-ray and sputum test for *acid-fast bacilli* for male and female control subjects.

The chest x-ray and sputum test for *acid-fast bacilli* results for male and female control subjects are shown in Tables 4.1o (i) and 4.1o (ii). The average value of the cardiothoracic ratio recorded was 0.35±0.05cm. The ratio was correlated with the age of the workers, which is illustrated in Figure 4.1m. The correlation coefficient was 0.894427191 for both males and females. The transverse cardiac diameter average value of 15.28±0.05cm for the males and 14.23±0.05cm for the female were recorded. The mediastinum posterior-anterior view has a centrally located position, as well as the trachea. The right atrium, the ascending aorta and superior vena cava were contained in the right contour of the mediastinum. The right ventricle partially overlaid the left ventricle. The left atrium was located inferior to the left pulmonary hilum. The left ventricle prominently rounded apex of the heart and great vessels were viewed as frontal projection.

The lateral view of the chest x-ray showed that the left pulmonary artery was coursing superiorly and posteriorly relative to the right side of the mediastinum while the left ventricle slopped inferiorly. There was no evidence of mitral stenosis, chronic obstructive pulmonary disease, atelectasis or lung parenchyma involvement with fine or coarse reticular opacities or small nodules. The Lung borders; thoracic spine, neck costophrenic angles, lung apices, retrocardiac space, and retrosternal space had no areas of opacities for infiltrates or masses. There was no consolidation of the lung seen on the posterior-anterior and lateral views of the chest x-ray of control subjects at various age groups as illustrated in Figure 4.1n. From the Sputum samples, there were no rod-shaped bacteria (bacilli) that was seen per hundred (100) fields under the microscope after the staining procedure. The *acid-fast bacilli* were not present.

Table 4.1o (i): Chest x-ray and sputum for the male control subjects

Age group (years)	Sex	No.	Chest X-Ray												Sputum	
			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Male	2	0.3	15.2	0	2	0	2	0	2	0	2	0	2	0	2
31-40	Male	1	0.3	15.3	0	1	0	1	0	1	0	1	0	1	0	1
41-50	Male	2	0.4	15.3	0	2	0	2	0	2	0	2	0	2	0	2
51-60	Male	2	0.4	15.3	0	2	0	2	0	2	0	2	0	2	0	2
Average/Standard deviation			0.35±0.06	15.28±0.05	0	1.75±0.50	0	1.75±0.50	0	1.75±0.50	0	1.75±0.50	0	1.75±0.50	0	1.75±0.50

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels, LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, AFB - *Acid-fast bacilli.*

Table 4.1o (ii): Chest x-ray and sputum for the female control subjects

Age group (years)	Sex	No.	Chest X-Ray												Sputum	
			HSS		PBV		Lung Field		Lung borders							
									Diaphragm		Heart		Mediastenum			
			CTR	TCD	Dx.	N	C	N	Dx.	N	Dx.	N	Dx.	N	AFB	N
21-30	Female	3	0.3	14.2	0	2	0	2	0	2	0	2	0	2	0	2
31-40	Female	2	0.3	14.2	0	2	0	2	0	2	0	2	0	2	0	2
41-50	Female	1	0.4	14.2	0	1	0	1	0	1	0	1	0	1	0	1
51-60	Female	2	0.4	14.3	0	1	0	1	0	1	0	1	0	1	0	1
			0.35	14.225		1.5	0	1.5	0	1.5	0	1.5	0	1.5	0	1.5
Average/Standard deviation			0.35±0.06	14.23±0.05	0	1.5±0.60	0	1.5±0.60	0	1.5±0.60	0	1.5±0.60	0	1.5±0.60	0	1.5±0.60

Legend: HSS - Heart size and shape, CTR - Cardiothoracic ratio, TCD - Transverse cardiac diameter, PBV - Pulmonary blood vessels, LF - Lung field, C - Consolidation, N - Normal, Dx - Disease, AFB - *Acid-fast bacilli.*

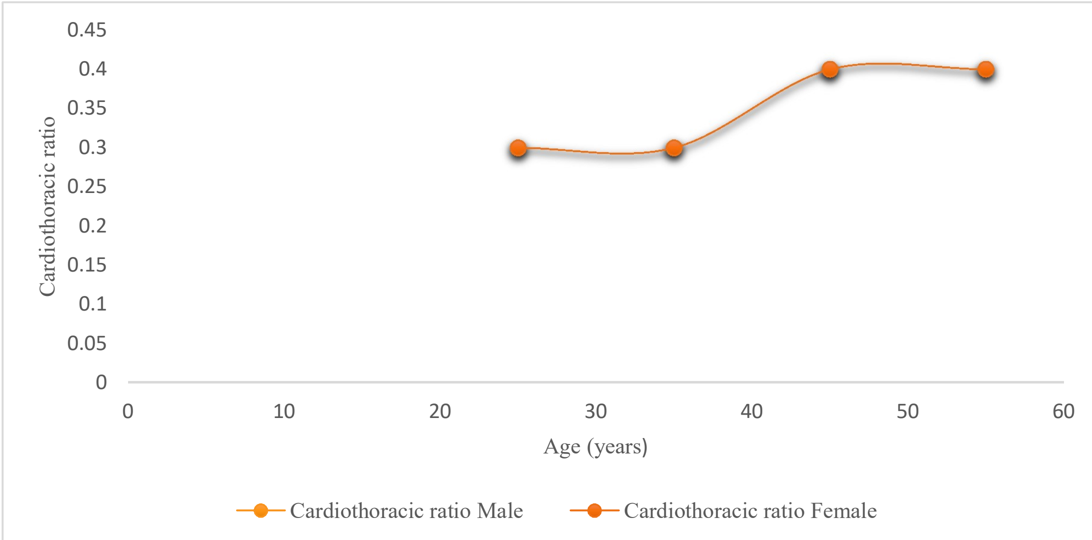

Figure 4.1n: Correlation of cardiothoracic ratio with the age of the control subjects.

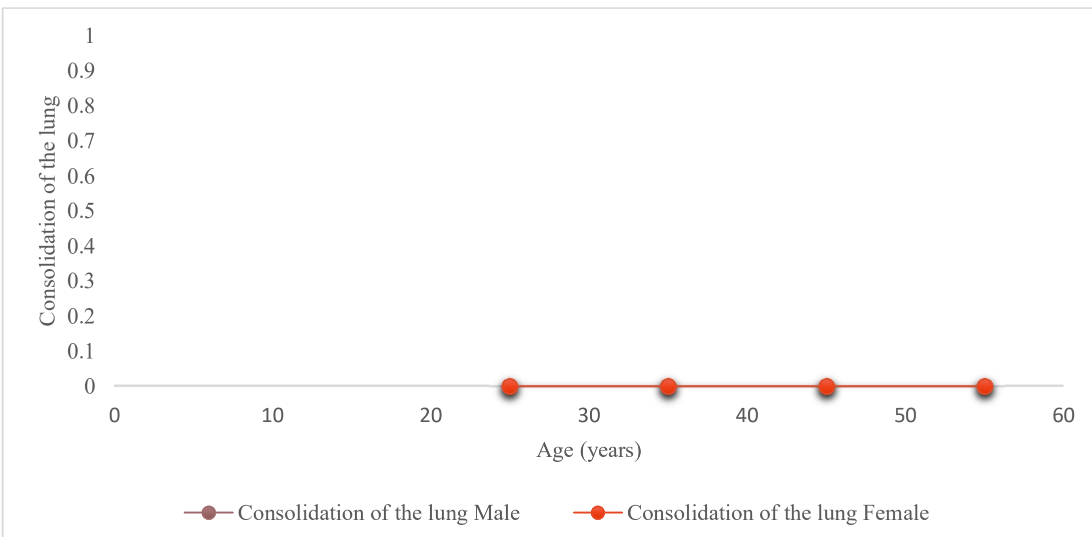

Figure 4.1o: Correlation of consolidation of the lung with the age of the control subjects.

4.1.3.2 Results of full blood count and erythrocyte sedimentation rate (ESR) for male and female control subjects.

Table 4.1p (i) shows the result of full blood count and erythrocyte sedimentation rate (ESR) for male control subject. The full blood count for this group recorded was, 76.43±6.65% for the average haemoglobin values, and the total white blood cell count was 5485.71±595.62 mcl. Regarding the direct count, the neutrophils were 49.57±1.72%; lymphocytes, 39.29±6.40%; monocytes, 2.14±1.57%; basophils, 0.00±0.00% and eosinophils, 4.86±0.00%. The erythrocyte sedimentation rate recorded was 22.14±1.86 mm/hr.

Table 4.1p (ii) shows the result of full blood count and erythrocyte sedimentation rate (ESR) for female control subjects. The full blood count for the female control group recorded were 69.25±7.72% for the average haemoglobin values and 4887.50±343.08 mcl for the total white blood cell count. For the direct count, the neutrophils were 47±3.81%; lymphocyte, 42.12±083%; monocytes, 3.13±0.99%; basophils, 0.00±0.00% and eosinophil, 4.62±1.60%. The erythrocyte sedimentation rate recorded was 24.13±1.81 mm/hr.

Table 4.1p (i): Full blood count and erythrocyte sedimentation rate (ESR) for male control subjects in South-Eastern Nigeria

Age group (years)	Sex	No.	Full Blood Count								Erythrocyte Sedimentation Rate (mm/hr.)
			Haemoglobin	White Blood Cell							
				Total count	Direct count						
					Neutrophil	Lymphocyte	Monocytes	Basophil	Eosinophil		
21-30	Male	2	84	5350	48	30	0	0	5		22
31-40	Male	1	69	4800	48	42	3	0	9		22
41-50	Male	2	79	5450	51	44	3	0	3		24
51-60	Male	2	70	6000	50.5	42.5	3	0	4.5		21
Mean / Standard deviation			76.43±6.65	5485.71±595.62	49.57±1.72	39.29±6.40	2.25±1.50	0.00±0.00	4.86±2.19		22.14±1.86
Normal range: FBC and ESR.	Male:		14-18g/dl	4,500-10,000mcl	(40–80%)	20–40%	2–10%	< 1–2%	1–6%		0-22 mm/hr.

Table 4.1p (ii): Full blood count and erythrocyte sedimentation rate (ESR) for female control subjects

Age group	Sex	No.	Full Blood Count							Erythrocyte Sedimentation Rate (mm/hr.)
(years)			Haemoglobin	White Blood Cell						
				Total count	Direct count					
					Neutrophil	Lymphocyte	Monocytes	Basophil	Eosinophi	
21-30	Female	3	74	5033.33	42.67	42.67	2.67	0	4.67	23
31-40	Female	2	59.5	4600	46.00	41	3	0	6	25
41-50	Female	1	75	4500	49	43	3	0	5	27
51-60	Female	2	69	5150	51	22	4	0	3	24
Mean / Standard deviation			69.25±7.72	4887.50±343.08	47±3.81	42.12±083	3.13±0.99	0.00±0.00	4.62±1.60	24.13±1.81
Normal range: FBC and ESR.			12-16g/dl	4,500-10,000mcl	(40–80%)	(20–40%)	(2–10%)	(< 1–2%)	(1–6%)	0-29 (mm/hr.)

4.1.4 Results of air quality assessment in some industries in South-Eastern Nigeria.

The mean values of air quality assessment in some industries in South Eastern Nigeria are shown in Table 4.2. The mean values of NO_2 in healthcare (0.08±0.01 ppm[a]) and brewery (0.08±0.01ppm[a]) industries were not significantly different ($p>0.05$) from their controls. The mean values of NO_2 in the quarry (0.65±0.32 ppm[b,c]); road construction (0.93±0.22 ppm[c]) and asphalt (1.33±0.29 ppm[d]) industries, were significantly different ($p<0.05$) from their controls. For CO_2, the mean values in the quarry (13.83±1.86%[b]) and asphalt (17.83±1.69%[b]) industries, were not significantly different ($p>0.05$) from their controls. The mean values of CO_2 in healthcare (13.27±1.13%[b]); road construction (14.13±3.10%[b]) and brewery (29.27±10.18%[c]) industries, were significantly different ($p<0.05$) from their controls. For CO, the mean values in road construction (9.18±5.50 ppm[a,b]) and brewery (4.00±2.55 ppm[a]) industries, were not significantly different ($p>0.05$) from their controls. The mean values of CO in healthcare (13.27±1.13 ppm[a]); quarry (1.7×10^1±3.05 ppm[c]) and asphalt (42.90±2.29 ppm[d]) industries, were significantly different ($p<0.05$) from their controls. For SO_2, the mean values in healthcare (0.8±1.13 ppm[a,b]); quarry (1.15±0.38 ppm[b]); road construction (1.05±0.38 ppm[a,b]); asphalt (4.73±0.15 ppm[c]) and brewery (0.80±0.98 ppm[a,b]) industries, were significantly different ($p<0.05$) from their controls.

The mean values for VOCs, in healthcare (0.53±0.34 ppm[a]); quarry (0.40±0.20 ppm[a]); road construction (0.80±0.00 ppm[a]) and brewery (0.47±0.34[a]) industries, were not significantly different ($p>0.05$) from their controls. The mean value of VOCs in asphalt (6.43±1.88 ppm[c]) industry, was significantly different ($p<0.05$) from the control (3.00±0.82 $\mu g/m^{3}$[b]). For $TSPM_{10}$, the mean values in healthcare (5.57±3.23 $\mu g/m^{3}$[a]) and brewery (5.19±2.67 $\mu g/m^{3a}$) industries, were not significantly different ($p>0.05$) from their controls. The mean values of TSPM10 in the quarry (59.7±22.53 $\mu g/m^{3c}$); road construction (62.00±15.87 $\mu g/m^{3c}$) and asphalt (92.35±3.02 $\mu g/m^{3d}$) industries, were significantly different ($p<0.05$) from their controls. Air quality as regards to the gases analysed in the study showed that the asphalt industry had mean values well above the NESREA (1991) standard hence, had the poorest air quality. The air quality (NO_2, CO_2, CO, SO_2, VOC, PM_{10} $\mu g/m^3$) average, with vertical error bars in the industries studied, are shown in Figures 4.2 (i) to Figure 4.2 (vi).

Table 4.2: Air quality assessment in some industries, South-Eastern Nigeria

	Healthcare		Quarry		Road construction		Asphalt		Brewery		NESREA
Parameters	Average	Control	Average	Control	Average	Control	Average	Control	Average	Control	(1991)
NO_2, ppm	0.08 ± 0.02^{a}	NS	$0.65\pm0.37^{b,c}$	NS	0.93 ± 0.25^{c}	0.06 ± 0.01^{a}	1.33 ± 0.34^{d}	0.45 ± 0.01^{b}	0.08 ± 0.01^{a}	NS	0.04-0.06
CO_2 (%)	13.27 ± 1.13^{b}	$4.00\pm0.82^{a,b}$	13.83 ± 1.86^{b}	12.20 ± 0.10^{b}	14.13 ± 3.10^{b}	$11.20\pm0.10^{a,b}$	17.83 ± 1.69^{b}	15.20 ± 0.10^{b}	29.27 ± 11.76^{c}	$11.20\pm0.10^{a,b}$	10
CO, ppm	4.00 ± 3.60^{a}	11.2 ± 0.20^{b}	$1.7X10^{1}\pm3.52^{c}$	$6.00\pm2.00^{a,b}$	$9.18\pm6.35^{a,b}$	4.00 ± 1.00^{a}	42.90 ± 3.37^{d}	4.00 ± 1.00^{a}	4.00 ± 2.94^{a}	4.00 ± 1.00^{a}	NS
SO_2, ppm	$0.8\pm1.39^{a,b}$	NS	1.15 ± 0.44^{b}	$0.30\pm0.20^{a,b}$	$1.05\pm0.44^{a,b}$	NS	4.73 ± 0.17^{c}	$0.40\pm0.10^{a,b}$	$0.80\pm1.13^{a,b}$	0.01 ± 0.00^{a}	0.01
VOCs, ppm	0.53 ± 0.42^{a}	NS	0.20 ± 0.28^{a}	0.20 ± 1.00^{a}	0.20 ± 0.40^{a}	NS	6.43 ± 2.17^{c}	3.00 ± 1.00^{b}	0.47 ± 0.39^{a}	NS	NS
$TSPM_{10}$ µg/m³	5.57 ± 3.96^{a}	5.60 ± 0.10^{a}	59.70 ± 26.02^{c}	$40.60\pm0.10^{b,c}$	62.00 ± 37.32^{c}	$30.60\pm0.10^{a,b}$	92.35 ± 3.49^{d}	$40.60\pm0.10^{b,c}$	5.19 ± 3.09^{a}	4.30 ± 0.03^{a}	0.25

Legend: NS - None specified, % - percent, ppm - parts per million, µgm/m³, NESREA - National Environmental Standards and Regulations Enforcement Agency (Nigeria)

Values with the same superscript across rows are not significantly different (P>0.05)

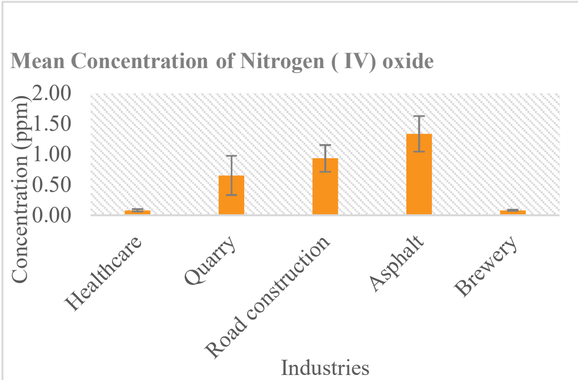

Figure 4. 2 (i): Mean concentration of nitrogen (IV) oxide with vertical error bars

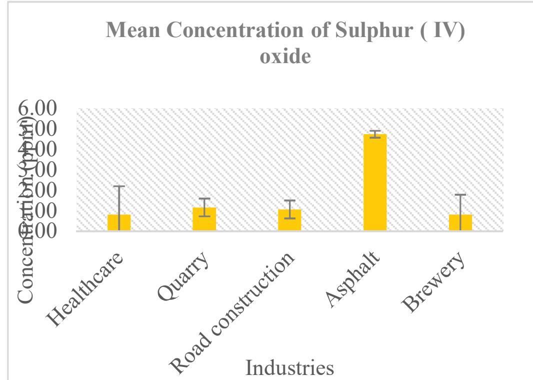

Figure 4. 2 (iv): Mean concentration of sulphur (IV) oxide with vertical error bars

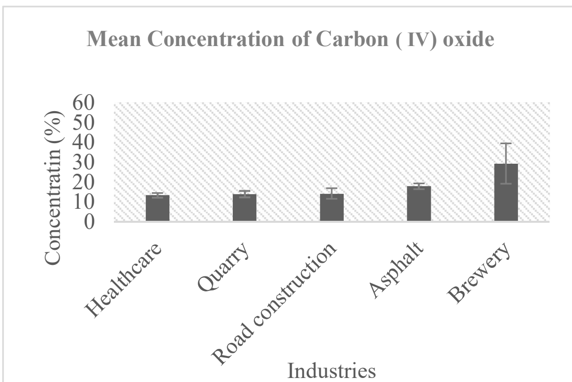

Figure 4. 2 (ii): Mean concentration of Carbon (IV) oxide with vertical error bars

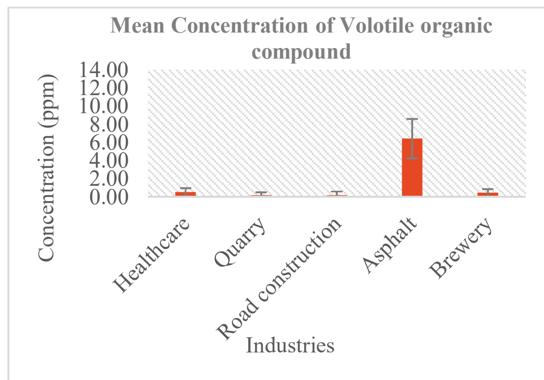

Figure 4. 2 (v): Mean concentration of Volatile organic compound with vertical error bars

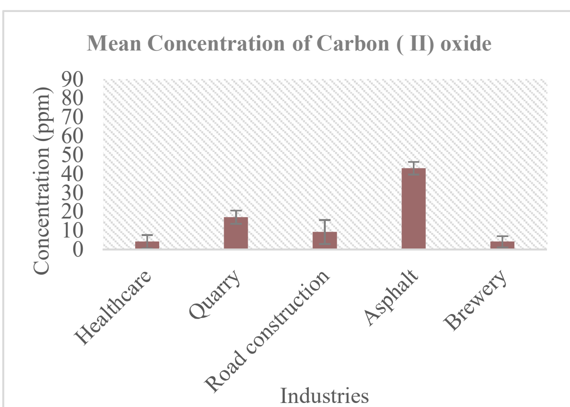

Figure 4. 2 (iii): Mean concentration of carbon (II) oxide with vertical error bars

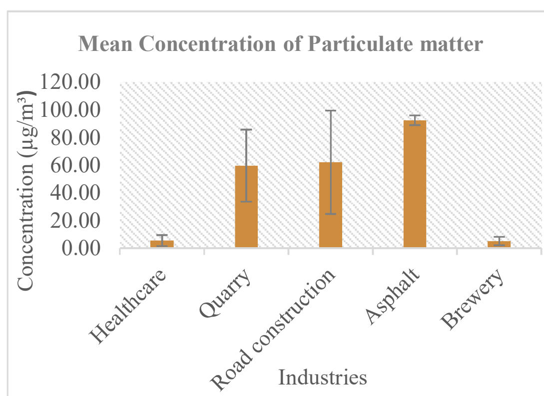

Figure 4. 2 (vi): Mean concentration of particulate matter with vertical error bars

4.1.5 Result of physicochemical and microbial analyses of water in some industries, South-Eastern Nigeria

The mean values of physicochemical and microbial analysis of water in some industries, South-Eastern Nigeria, are shown in Table 4.3. The mean value of temperature in brewery (27.17±0.06°C^{a}) industry, was not significantly different (p>0.05) from the control, while the mean values of temperature in the quarry (33.20±1.97°C^{c}); healthcare (29.27±0.90°C ^{a,b}); road construction (27.40±0.20°C^{a}) and asphalt (30.50±2.19°C^{b}) industries were significantly different (p<0.05) from the control (30.00±2.65°C^{a,b}). The peak value of temperature were recorded in the quarry industry. For pH, the mean values in healthcare (8.07±2.11^{a}); quarry (7.03±1.50^{a}); road construction (6.82±0.64^{a}); asphalt (7.62±2.46^{a}) and brewery (6.59±0.93^{a}) industries were not significantly different (p>0.05) from their controls. The peak value of pH (8.07±2.11) was recorded in Nworie river near healthcare industry, Owerri while Njaba river near breweries, Awo-omamma had the least pH of 6.59±0.93. The mean values for conductivity, in healthcare (2658.00±4505.08 µS/cm^{a}); quarry (6262.67±10503.89 µS/cm^{a}); road construction (55.33±8.50 µS/cm^{a}); asphalt (1300.77±2030.65 µS/cm^{a}) and brewery (16.67±5.77 µS/cm^{a}) industries, were not significantly different (p>0.05) from their controls. The conductivity mean values was lowest (16.67±5.77 µS/cm) at Awo-omamma and highest (6262.67±10503.89 µS/cm) in Akpoha river near quarry industry, Ishiagu.

The mean values for total dissolved solids, in healthcare (1596.70±2701.40 mg/l^{a}); quarry (484.68±624.84 mg/l^{a}); road construction (35.97±6.77 mg/l^{a}); asphalt (848.50±1317.43 mg/l^{a}) and brewery (10.83±3.06 mg/l^{a}) industries, were not significantly different (p>0.05) from their controls. The total dissolved solids ranged between 10.83±3.06 mg/l (in Njaba river) and 1.596.7 ± 208.0 mg/l (in Nworie river). For dissolved oxygen, the mean values in healthcare (3.97±0.85 mg/l^{a,b,c}) and brewery (5.07±0.15 mg/^{lb,c}) industries, were not significantly different ($p>0.05$) from their controls while the mean values of dissolved oxygen in quarry (3.57±0.90 mg/l[b,c]); asphalt industry (2.67±1.59 mg/l[a]) and road construction (3.57±0.90 mg/l[a,b]) were significantly different from their controls. The peak value of dissolved oxygen (5.07±0.15 mg/l) was recorded at Njaba river near the brewery, Awo-omamma. For biochemical oxygen demand, the mean values in quarry (1.90±0.78 mg/l[a]); asphalt (1.60±0.70 mg/l[a]) and brewery (1.97±0.84 mg/l[a]) industries, were not significantly different ($p>0.05$) from their controls, while the mean value of biochemical oxygen demand in the healthcare (4.40±2.77 mg/l[b]) and road construction (1.90±0.78 mg/l[a]) industries, were significantly different ($p<0.05$) from their controls. Biochemical oxygen demand, values were between 1.60±0.70 mg/l (in the asphalt, Enugu) and 4.40±2.77 mg/l (in the healthcare, Owerri) industries.

The mean values for nitrate (NO_3^-), in quarry (30.67±24.39 mg/l[a]); road construction (27.85±22.25 mg/l[a]); asphalt (8.17±5.78 mg/l[a]) and brewery (15.27±2.85 mg/l[a]) industries, were not significantly different ($p>0.05$) from their controls, while the mean value (151.38±200.97 mg/l[c]) of nitrate in the healthcare industry was significantly different ($p<0.05$) from the control (15.10±3.44 mg/l[a]). The mean values of nitrate-nitrogen (NO_3^- - N), in quarry (7.11±4.40 mg/l[a]); road construction (6.23±4.88 mg/l[a]); asphalt (1.83±1.31 mg/l[a]) and brewery (3.44±0.64 mg/l[a]) industries, were not significantly different ($p>0.05$) while the mean value (34.13±37.09 mg/l[b]) of nitrate-nitrogen in healthcare industry was significantly different ($p<0.05$) from the control (3.20±0.22mg/l[a]). The mean values of NO_3^- - N, were between 1.83±1.31 mg/l (in river Akpou-ga Nike near asphalt industry Enugu) and 34.13±45.42 mg/l (in Nworie river near healthcare industry, Owerri). For phosphate (PO_4^{3-}), the mean values in the quarry (3.67±3.80 mg/l[a,b]) and road construction (11±3.50 mg/l[a,b]) industries, were not significantly different ($p>0.05$ from their controls. The mean values of phosphate in healthcare (14.90±5.35 mg/l[b]); asphalt (4.13±5.13 mg/l[a]) and brewery (5.95±8.22 mg/l[a]) industries were significantly different (p<0.05 from their controls. Phosphate (PO_4^{-3}), recorded was between 3.67±3.80 mg/l (in the quarry, Ishiagu), and 14.90±5.35 mg/l (in the healthcare industry, Owerri). For phosphorus (P), the mean values in road construction (3.57±1.08 mg/l[a,b]) industry was not significantly different (p>0.05) from the control, while healthcare (4.79±1.68 mg/l[b]); quarry (1.33±1.10 mg/l[a]); asphalt (1.33±1.63 mg/l[a]) and brewery (1.95±2.69 mg/l[a]) industries were significantly different (p<0.05) from their control. Phosphorous (P), recorded was lowest (1.33±1.10 mg/l) in the quarry, Ishiagu and highest (4.79±1.68 mg/l) in the healthcare industry, Owerri. The mean values for lead (Pb), in road construction (0.12±0.01 mg/l[a]) and asphalt (0.3±0.02 mg/l[a]) industries, were not significantly different (p>0.05 from their controls while the mean values in healthcare (1.87±1.92 mg/l[b]); quarry (0.23±0.14 mg/l[a]); and brewery (0.00±0.00 mg/l[a]) industries, were significantly different (p<0.05) from their controls. Among all the heavy metals assessed, Pb recorded the highest average value of 1.86±1.92 mg/l in Nworie river.

The mean values of cadmium (Cd), in road construction (1.47±2.16 mg/l[b]) industry, was not significantly different (p>0.05) from the control. The mean values of cadmium in healthcare (0.17±0.10 mg/l[a]); quarry (0.13±0.01 mg/l[a] asphalt (0.09±0.01 mg/l[a]) and brewery (0.01±0.02 mg/l[a]) industries were significantly different (p<0.05) from their controls. The peak values of Cd (0.17±0.10 mg/l), Cr (0.18±0.09 mg/l) and As (0.13 ± 0.08 mg/l) was recorded in Nworie river, Owerri. The mean values of mercury (Hg), in healthcare (0.10±0.07 mg/l[b]); road construction (0.14±0.01 mg/l[b,c]) and asphalt (0.13±0.01 mg/l[b,c]) industries, were not significantly different (p>0.05) from their controls, while the mean value (0.01±0.01 mg/l[a]) of mercury in brewery and quarry (0.14±0.03 mg/l[c]) industries, were significantly different (p<0.05) from their controls. Mercury had the peak value of 0.14±0.03 mg/l in the Akpoha river near the quarry industry, Ishiagu. For arsenic (As), the mean values in the quarry (0.02±0.01 mg/l[a]) and asphalt (0.02±0.00 mg/l[a]) industries, were not significantly different (p>0.05) from their controls. The mean values of arsenic in healthcare (0.13±0.10 mg/l[a,b]); road construction (0.09±0.01 mg/l[a,b]) and brewery (0.18±0.23 mg/l[b]) industries, were significantly different (p<0.05 from their controls. The peak value of As (0.13 ± 0.10 mg/l) was recorded in Nworie river, Owerri. The mean values of chromium (Cr) in all the industries studied: healthcare (0.12±0.14 mg/l[b]); quarry (0.09±0.03 mg/l[b]); road construction (0.16±0.09 mg/l[b]); asphalt (0.10±0.02 mg/l[a,b]) and brewery (0.01±0.01 mg/l[a]), were significantly different (p<0.05) from their controls. The peak value of Cr (0.12±0.14 mg/l) was recorded in Nworie river, Owerri.

In microbial analysis of water, the mean values of total bacteria count in all the industries studied: healthcare (2.9×10^5±3.0 CFU/ml[a,b]); quarry (85×10^5±9.1 CFU/ml[b]) road construction (3.1×10^5±2.6 CFU/ml[a,b]); asphalt (7.3×10^5±6.6 CFU/ml[a.b]) and brewery (5.3×10^5±4.6 CFU/ml[a,b]) industries, were significantly different (p<0.05) from their controls. The total bacteria count was 7.3×10^5 CFU/ml in the river near asphalt, Enugu but least (2.1×10^5 CFU/ml) in Nworie river. The mean values of total petroleum heterotrophic bacteria, in healthcare (4.0×10^0±6.00[a] CFU/ml[a]); quarry (4.0×10^3±5.7×10^3 CFU/ml[a,b]); road construction (0.00±0.00 CFU/ml[a]) and brewery (5.7×10^3±3.1 $\times 10^3$ CFU/ml[a,b]) industries, were not significantly different (p>0.05) from their controls while the mean value (6.3×10^3±6.8×10^3 CFU/ml[b]) of total petroleum heterotrophic bacteria, in the asphalt industry, was significantly different (p<0.05) from the control (0.00±0.00 CFU/ml[a]). The mean values of total petroleum heterotrophic bacteria were highest in the asphalt industry, and there was no growth in the road construction industry. For total fungi count, the mean values in healthcare (3.3×10^3±4.2 CFU/ml[a]); road construction (4.7×10^3±3.1 CFU/ml[a]); asphalt (2.1×10^3±2.2 CFU/ml[a]) and brewery (3.7×10^3±1.1 CFU/ml[a]) industries, were not significantly different (p>0.05) from their controls while the mean value (5.7×10^5 CFU/ml[b]) of total fungi count, in Akpoha river near quarry (5.3×10^5±6.7 CFU/ml[b]) industry, was significantly different (p<0.05) from the control

(1.0×10^3 CFU/ml[a]). The values of the total fungal count were rather least (2.0×10^3 CFU/ml) in asphalt, Enugu but highest (3.5×10^5 CFU/ml) in Akpoha river near quarry industry, Ishiagu. For total petroleum heterotrophic, the mean values in healthcare (1.8x10±1.2 CFU/ml[a]); in quarry ($1.3 \times 10^3 \pm 1.8$ CFU/ml[a]); road construction (1.6x10±1.5 CFU/ml[a]); asphalt (NG) and brewery ($3.0 \times 10^2 \pm 1.0$ CFU/ml[a]) industries, were not significantly different ($p>0.05$) from their controls. The peak value of total petroleum heterotrophic was recorded in the brewery industry, and there was no growth in the asphalt industry. The mean values of pH and heavy metals in water, with vertical error bars for the industries studied, are shown in Figures 4.3 (i) to Figure 4.3 (vi).

Table 4.3: Physicochemical and microbial analyses of water near some industries in South-Eastern Nigeria

Parameters	Healthcare		Quarry		Road construction		Asphalt		Brewery		FMEnv. Standard 1991
	Average	Control	Average	Control	average	Control	average	Control	average	Control	
Temperature, °C	29.27±0.90^{a,b}	27.20±2.78^{a}	33.20±1.97^{c}	30.00±2.65^{a,b}	28.73±0.42^{a,b}	27.40±0.20^{a}	30.50±2.19^{b,c}	28±1.00^{a,b}	27.17±0.06^{a}	27.17±0.10^{a}	
ph	8.07±2.11^{a}	6.30±0.10^{a}	7.03±1.50^{a}	7.03±0.01^{a}	6.82±0.64^{a}	6.07±0.02^{a}	7.62±2.46^{a}	6.38±0.45^{a}	6.59±0.93^{a}	6.03±0.02^{a}	
Conductivity, µS/cm	2658.00±4505.08^{a}	10.00±3.61^{a}	6262.67±10503.89^{a}	1000.00±100.00^{a}	55.33±10.41^{a}	10.00±2.65^{a}	1300.77±2030.65^{a}	80.00±9.54^{a}	16.67±5.77^{a}	10.00±0.50^{a}	
Total Dissolved Solids, mg/l	1596.70±2701.40^{a}	6.50±0.26^{a}	484.68±624.84^{a}	405.00±2.65^{a}	35.97±6.77^{a}	6.50±0.20^{a}	848.50±1317.43^{a}	46.5±0.40^{a}	10.83±3.06^{a}	6.50±0.10^{a}	
Dissolved Oxygen, mg/l	3.97±0.85^{a,b}	4.00±1.00^{a,b}	3.57±1.67^{a,b}	4.80±0.10^{b}	3.57±0.90^{a,b}	4.80±0.10^{b}	2.67±1.59^{a}	4.80±0.17^{b}	5.07±0.15^{b}	4.80±0.36^{b}	
Biochemical Oxygen Demand, mg/l	4.40±3.39^{b}	0.80±0.10^{a}	1.90±0.78^{a}	0.47±0.32^{a}	2.40±0.26^{a,b}	0.80±0.17^{a}	1.60±0.70^{a}	0.80±0.10^{a}	1.97±1.03^{a}	0.80±0.10^{a}	
Nitrate (NO^-_3), mg/l	151.38±200.97^{b}	15.10±3.44^{a}	30.67±24.39^{a}	14.10±0.10^{a}	27.85±22.25^{a}	14.10±0.10^{a}	8.17±5.78^{a}	10.10±0.10^{a}	15.27±2.85^{a}	14.10±0.10^{a}	
Nitrate-Nitrogen (NO^-_3 - N), mg/l	34.13±45.42^{b}	3.20±0.26^{a}	7.11±4.40^{a}	3.20±0.10^{a}	6.23±4.88^{a}	3.20±0.10^{a}	1.83±1.31^{a}	3.20±0.10^{a}	3.44±0.64^{a}	3.15±0.14^{a}	
Phosphate (PO_4^{3-}), mg/l	14.90±5.35^{b}	10.20±1.05^{a,b}	3.67±3.80^{a}	6.30±0.26^{a}	11±3.5^{a,b}	10.30±0.10^{a,b}	4.13±5.13^{a}	10.30±0.10^{a,b}	5.95±8.22^{a}	10.30±0.10^{a,b}	
Phosphorus (P), mg/l	4.79±1.68^{b}	3.30±0.26^{a,b}	1.33±1.10^{a}	3.30±0.10^{a,b}	3.57±1.08^{a,b}	3.50±0.46^{a,b}	1.33±1.63^{a}	3.30±0.63^{a,b}	1.95±2.69^{a}	3.30±0.30^{a,b}	
Lead (Pb), mg/l	1.87±1.92^{b}	1.05±0.00^{a,b}	0.23±0.14^{a}	1.05±0.00^{a,b}	0.12±0.01^{a}	0.10±0.00^{a}	0.30±0.02^{a}	0.05±0.00^{a}	0.00±0.00^{a}	1.05±0.00^{a,b}	< 1
Cadmium (Cd), mg/l	0.17±0.10^{a}	0.10±0.00^{a}	0.13±0.01^{a}	0.10±0.00^{a}	1.47±2.16^{b}	1.050±0.00^{a,b}	0.09±0.01^{a}	0.10±0.00^{a}	0.01±0.02^{a}	0.10±0.02^{a}	< 1
Mercury (Hg), mg/l	0.10±0.07^{b}	0.10±0.00^{b}	0.14±0.03^{c}	0.11±0.00^{b,c}	0.14±0.01^{b,c}	0.11±0.00^{b,c}	0.13±0.02^{b,c}	0.11±0.00^{b,c}	0.01±0.01^{a}	0.11±0.00^{b,c}	0.05
Arsenic (As), mg/l	0.13±0.10^{a,b}	0.01±0.00^{a}	0.02±0.01^{a}	0.01±0.00^{a}	0.09±0.01^{a,b}	0.01±0.00^{a}	0.02±0.00^{a}	0.02±0.00^{a}	0.18±0.23^{b}	0.01±0.00^{a}	0.1
Chromium Cr, mg/l	0.12±0.14^{b}	0.26±0.00^{c}	0.09±0.03^{a,b}	0.55±0.03^{d}	0.16±0.09^{b}	0.36±0.00^{c}	0.10±0.02^{a,b}	0.36±0.00^{c}	0.01±0.01^{a}	0.36±0.00^{c}	< 1
Total Bacterial Count, CFU/ml	2.9x10^{5}±3.0x10^{5a}	5.8x10^{2}±3.9x10^{2a}	5.7x10^{5}±8.1x0^{5b}	1.0x10^{3}±2x10^{2a}	3.1x10^{5}±2.6x10^{5a}	1.0x10^{3}±3.6x10^{2a}	7.3x10^{5}±8.1x10^{5a}	1.0x10^{3}±2.0x10^{2a}	5.3x10^{5}±4.6x10^{5a}	9.6x10^{2}±1.5x10^{2a}	
Total hydrocarbon utilizing bacterial (HUB) count,	4.0x10^{o}±6.00^{a}	NG	3.0x10^{3}±4.3x10^{3a}	NG	NG	NG	5.6x10^{3}±8.2x10^{3a}	NG	5.7x10^{3}±3.1 x10^{3a}	NG	
Total Fungi Count, CFU/ml	3.3x10^{3}±4.2x10^{3a}	1.0x10^{3}±1.0x10^{2a}	3.5x10^{5}±6.7x10^{5a}	1.0x10^{3}±3.0x10^{2a}	4.7x10^{3}±3.1x10^{3a}	8.3x10^{2}±1.5x10^{2a}	2.0x10^{3}±2.6x10^{3a}	1.0x10^{3}±3.0x10^{2a}	3.7x10^{3}±1.2x10^{3a}	NG	
Total hydrocarbon utilizing fungi (HUF) count, CFU/ml	1.8x10±1.2x10^{a}	NG	8.3x10^{3}±1.4x10^{3a}	NG	1.6x10±1.5x10^{a}	NG	NG	NG	3.0x10^{2}±1.0x10^{2a}	NG	

Legend: mg/l - milligram per litre, CFU/ml - Colony Forming Units per millilitre, µg/m³ - microgram per cubicmeter, NG - No growth.

Values with the same superscript across rows are not significantly different ($p>0.05$)

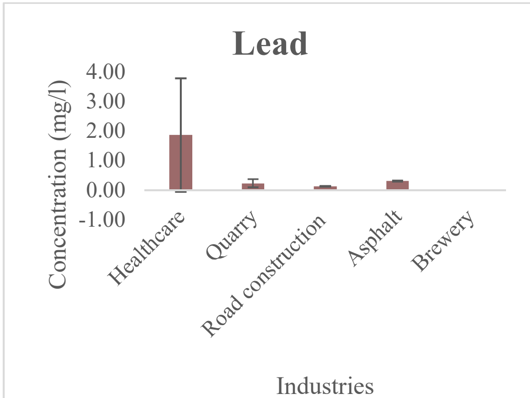

Figure 4. 3 (i): Mean concentration of lead in water with vertical error bars

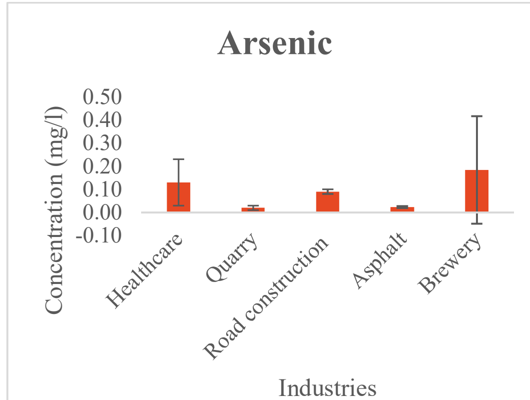

Figure 4. 3 (iv): Mean concentration of arsenic in water with vertical error bars

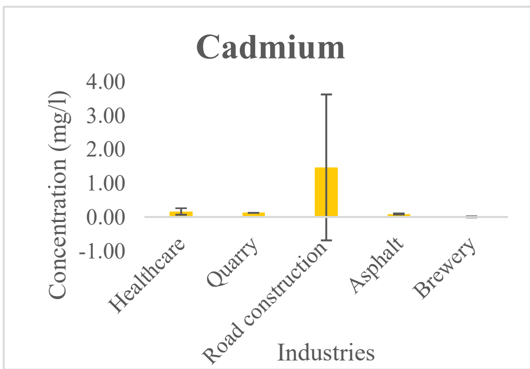

Figure 4. 3 (ii): Mean concentration of cadmium in water with vertical error

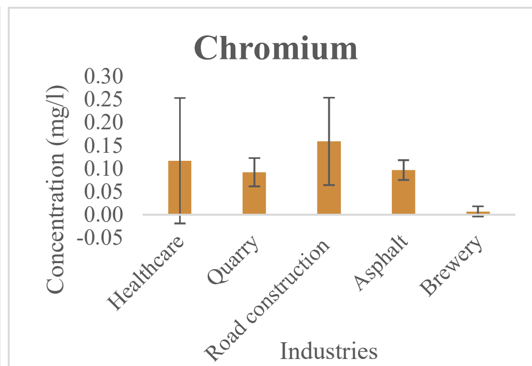

Figure 4. 3: (v) Mean concentration of chromium in water with vertical error

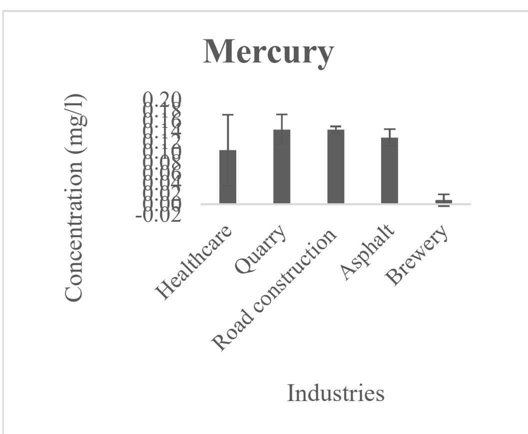

Figure 4. 3: (iii) Mean concentration of Mercury in water with vertical error bars

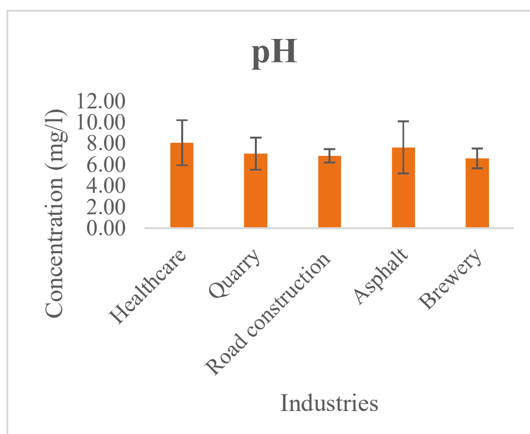

Figure 4. 3 (VI): Mean pH of water with vertical error bars

4.1.6 Results of physicochemical and microbial analyses of soil in selected industries, South-Eastern Nigeria.

Tables 4.4 shows the mean values of physicochemical and microbial analysis of soil samples collected near selected industries in South-Eastern Nigeria and values with the same superscript across rows were not significantly different ($p>0.05$). The mean values of pH in healthcare ($6.54±0.01^{c}$); quarry ($6.29±0.03^{b}$); road construction ($7.05±0.02^{e}$); asphalt ($1.96±0.02^{a}$) and brewery ($7.45±0.01^{f}$) industries had values with different superscript from their controls, and were significantly different ($p<0.05$). The pH values recorded were virtually below 7.0±0.00 except samples from road construction sites and brewery Awo-omamma that were above 7.0±0.00. For lead, the mean values in all the industries studied: healthcare (0.73±0.00 mg/kg^{e}); quarry (1.39±0.00 mg/kg^{g}); road construction (1.63±0.01 mg/kg^{i}); asphalt (0.45±0.00 mg/kg^{c}) and brewery (0.54±0.01 mg/kg^{d}) industries, were significantly different ($p<0.05$) from their controls. Similarly the mean values of cadmium, in all the industries studied: healthcare (0.14±0.00 mg/kg^{f}); quarry (0.09±0.00 mg/kg^{b}); road construction (0.13±0.01 mg/kg^{e}); asphalt (0.10±0.00 mg/kg^{c}) and brewery (0.13±0.00 $mg/kg^{e,f}$) industries were significantly different ($p<0.05$) from their controls. The mean values for mercury, in healthcare (0.11±0.01 mg/kg^{b}); road construction (0.11±0.00 mg/kg^{b}); asphalt (0.11±0.00 mg/kg^{b}) and brewery (0.12±0.00 mg/kg^{b}) industries were not significantly different ($p>0.05$) from their controls, while the mean value (0.07±0.01 mg/kg^{a}) of mercury in quarry industry was significantly different ($p<0.05$) from the control (0.11±0.00 mg/kg^{b}). For arsenic, the mean value (0.00±0.00 mg/kg^{a}) in brewery industry was not significantly different ($p>0.05$) from the control, while the mean values (0.00±0.00 mg/kg^{a}) of arsenic in healthcare (0.28±0.01 mg/kg^{f}); quarry (0.02±0.00 mg/kg^{b}); road construction (0.03±0.06 mg/kg^{e}) and asphalt (0.05±0.00 mg/kg^{c}) industries were significantly different ($p<0.05$) from the control. The mean values for chromium, in all the industries studied: healthcare (0.15±0.01 mg/kg^{d}); quarry (0.08±0.00 mg/kg^{b}); road construction (0.12±0.00 mg/kg[c]); asphalt (0.01±0.00 mg/kg[a]) and brewery (0.09±0.00 mg/kg[b]) industries, were significantly different ($p<0.05$) from their controls.

In microbial analysis of soil, the mean values of total bacteria count, in all the industries studied: healthcare ($6.2x10^6$±1.0 CFU/g[e]); quarry ($1.3x10^6$±1.0 CFU/g[c]); road construction ($1.2x10^6$±1.0 CFU/g[c]); asphalt ($2.6x10^5$±1.0 CFU/g[b]) and brewery ($4.8x10^6$±1.0 CFU/g[d]) industries, were significantly different ($p<0.05$) from their controls. For total petroleum heterotrophic bacteria, the mean values in healthcare ($2.4x10^3$±2.0 CFU/g[a]); quarry (NG); asphalt ($2.6x10^5$±1.0 CFU/g[b]) and brewery ($2.0x10^3$±1.0 CFU/g[a]) industries, were not significantly different ($p>0.05$) from their controls while the mean values ($1.0x10^4$±5.0 CFU/g[b]) of total petroleum heterotrophic bacteria in the road construction industry, was significantly different ($p<0.05$) from the control. For total fungi count, there were no growth (NG) in quarry and asphalt industries, were not significantly different ($p>0.05$) from their controls, while the mean values of total fungi count in healthcare ($5.0x10^3$±2.0 CFU/g[c]); road construction ($2.6x10^3$±2.0 CFU/g[b]) and brewery ($3.0x10^3$±1.0 CFU/g[b]) industries, were significantly different ($p<0.05$) from their controls. For total petroleum heterotrophic fungi in all the industries studied, healthcare ($1.8x10^4$±2.0 CFU/g[c]); quarry ($2.5x10^4$±1.0 CFU/g[d]); road construction ($6.5x10^4$±3.0 CFU/g[e]); asphalt ($1.0x10^3$±0.00 CFU/g[a]) and brewery ($1.8x10^4$±2.0CFU/g[c]) industries, were significantly different ($p<0.05$) from their controls. The mean values of pH and heavy metals in soil, with vertical error bars for the industries studied, are shown in Figure 4.4 (i) to Figure 4.4 (vi).

Table 4.4: Physicochemical and microbial analyses of soil near some industries, South-Eastern Nigeria

Parameters	Healthcare		Quarry		Road construction		Asphalt		Brewery		
	Average	Control	Average	Control	Average	Control	Average	Control	Average	Control	FMEnv. Standard 1991
Sand (%)	76.00 ± 0.44^{b}	70.00 ± 2.65^{a}	88.20 ± 0.90^{d}	$82.00\pm0.2.00^{c}$	76.40 ± 0.61^{b}	75.40 ± 0.10^{b}	84.00 ± 3.00^{c}	82.00 ± 2.65^{c}	71.00 ± 1.04^{a}	72.00 ± 2.38^{a}	
Silt (%)	$8.20\pm0.36^{a,b}$	$7.20\pm0.36^{a,b}$	$6.50\pm0.20^{a,b}$	6.10 ± 0.20^{a}	$8.40\pm053^{a,b}$	$8.30\pm0.20^{a,b}$	14.00 ± 3.61^{c}	13.00 ± 1.00^{c}	6.10 ± 0.36^{a}	8.67 ± 1.53^{b}	
Clay (%)	15.30 ± 0.87^{c}	14.40 ± 0.20^{c}	3.70 ± 0.20^{a}	3.20 ± 0.20^{a}	15.10 ± 0.20^{c}	14.93 ± 0.15^{c}	8.00 ± 1.00^{b}	8.00 ± 1.00^{b}	21.8 ± 0.10^{d}	22.00 ± 1.00^{d}	
Porosity (%)	28.00 ± 1.53^{a}	$30.00\pm1.00^{a,b}$	39.80 ± 0.79^{c}	40 ± 1.00^{c}	32.00 ± 2.65^{b}	36.00 ± 3.61^{c}	36.00 ± 4.36^{c}	40.00 ± 1.00^{c}	52.00 ± 2.00^{d}	50.00 ± 1.00^{d}	
Textural class	Loamy sand	Loamy sand	sandy	sandy	Loamy sand	Loamy sand	Sandy	Sandy	Loamy sand	Loamy sand	
pH	6.54 ± 0.01^{c}	6.97 ± 0.03^{d}	6.29 ± 0.03^{b}	6.95 ± 0.03^{d}	7.05 ± 0.02^{e}	6.95 ± 0.04^{d}	1.96 ± 0.02^{a}	6.95 ± 0.03^{d}	7.45 ± 0.01^{f}	6.95 ± 0.03^{d}	6.5
Lead mg/kg	0.73 ± 0.00^{e}	0.11 ± 0.00^{b}	1.39 ± 0.00^{g}	1.11 ± 0.00^{b}	1.63 ± 0.01^{i}	1.05 ± 0.00^{f}	0.45 ± 0.00^{c}	0.05 ± 0.00^{a}	0.54 ± 0.01^{d}	0.05 ± 0.00^{a}	0.05
Cadmium, (mg/kg)	0.14 ± 0.00^{f}	0.05 ± 0.00^{a}	0.09 ± 0.00^{b}	0.05 ± 0.00^{a}	0.13 ± 0.01^{e}	0.12 ± 0.00^{d}	0.10 ± 0.00^{c}	0.12 ± 0.00^{d}	$0.13\pm0.00^{e,f}$	0.12 ± 0.00^{d}	0.1
Mercury, (mg/kg)	0.11 ± 0.01^{b}	0.11 ± 0.00^{b}	0.07 ± 0.02^{a}	0.11 ± 0.00^{b}	0.11 ± 0.00^{b}	0.11 ± 0.00^{b}	0.11 ± 0.00^{b}	0.11 ± 0.00^{b}	0.12 ± 0.00^{b}	0.11 ± 0.00^{b}	0.02
Arsenic, (mg/kg)	0.28 ± 0.01^{f}	NS	0.02 ± 0.00^{b}	NS	0.12 ± 0.00^{e}	0.19 ± 0.00^{d}	0.05 ± 0.00^{c}	NS	NS	NS	0.05
Chromium, (mg/kg)	0.15 ± 0.01^{d}	0.02 ± 0.00^{a}	0.08 ± 0.00^{b}	0.19 ± 0.01^{d}	0.12 ± 0.03^{c}	0.19 ± 0.01^{d}	0.01 ± 0.00^{a}	0.19 ± 0.00^{d}	0.09 ± 0.00^{b}	0.19 ± 0.00^{d}	0.1
Total Bacterial Count, CFU/g	$6.2x10^{6}\pm1.0x10^{5e}$	$3.7x10^{4}\pm4.6x10^{4a}$	$1.3x10^{6}\pm1.0x10^{5c}$	$1.0x10^{4}\pm3.0x10^{3a}$	$1.2x10^{6}\pm1.0x10^{5c}$	$1.0x10^{4}\pm3.6x10^{3a}$	$2.6x10^{5}\pm1.0x10^{5b}$	$9.6x10^{3}\pm3.7x10^{3a}$	$4.8x10^{6}\pm1.0x10^{5d}$	$1.0x10^{4}\pm2.0x10^{3a}$	
Total hydrocarbon utilizing bacterial (HUB) count, CFU/ml	$2.4x10^{3}\pm2.0x10^{2a}$	NG	NG	NG	$1.0x10^{4}\pm5x10^{3b}$	NG	NG	NG	$2.0x10^{3}\pm1.0$	NG	NS
Total Fungi Count, CFU/g	$5.0x10^{3}\pm2.0x10^{2c}$	NG	NG	NG	$2.6x10^{3}\pm2.0x10^{2b}$	NG	NG	NG	$3.0x10^{3}\pm1.0x10^{3b}$	NG	NS
Total hydrocarbon utilizing fungi (HUF) count, CFU/ml	$1.8x10^{4}\pm2.0x10^{3c}$	$6.0x10^{3}\pm3.0x10^{3b}$	$2.5x10^{4}\pm1.0x10^{3d}$	$6.0x10^{3}\pm2.0x10^{2b}$	$6.5x10^{4}\pm3.0x10^{3e}$	$6.0x10^{3}\pm6.0\times10^{3b}$	$1.0x10^{3}\pm0.00^{a}$	$6.0x10^{3}\pm3x10^{2b}$	$1.8x10^{4}\pm2.0x10^{2c}$	$4.3x10^{3}\pm3.3x10^{3b}$	NS

Legend: mg/kg - milligram per killogram, CFU/g - Colony Forming Units per gram, NG - No growth, NS - None specified.

Values with the same superscript across rows are not significantly different ($p>0.05$)

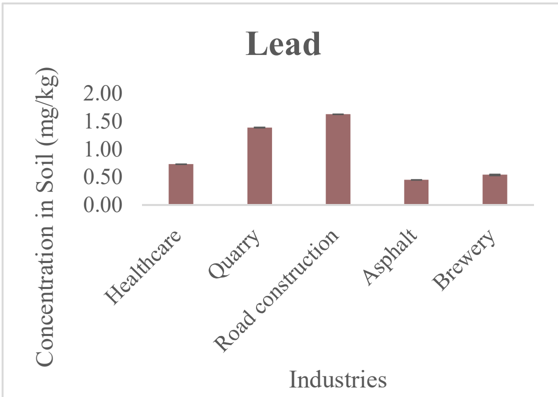

Figure 4. 4 (i): Mean concentration of lead in soil with vertical error bars.

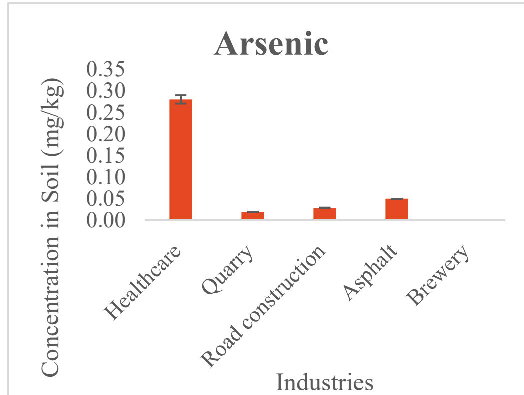

Figure 4. 4 (iv): Mean concentration of arsenic in soil with vertical error bars.

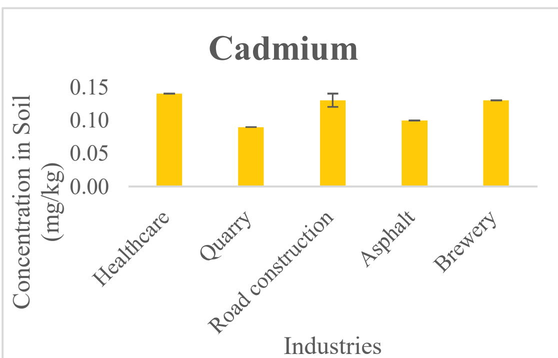

Figure 4. 4 (ii): Mean concentration of cadmium in soil with vertical error bars.

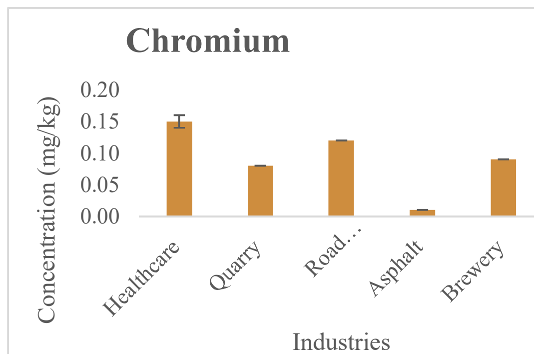

Figure 4. 4 (v): Mean concentration of chromium in soil with vertical error.

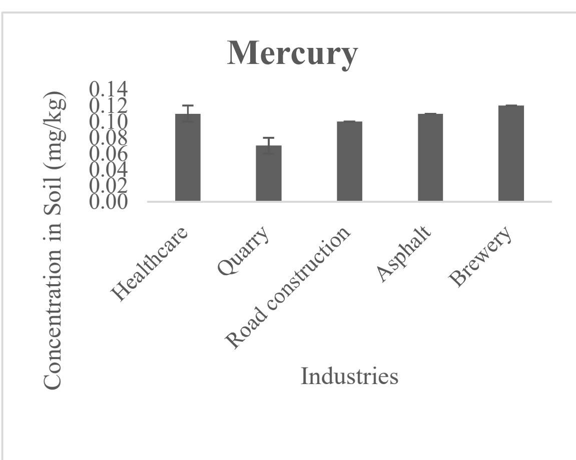

Figure 4. 4 (iii): Mean concentration of mercury in soil with vertical error bars.

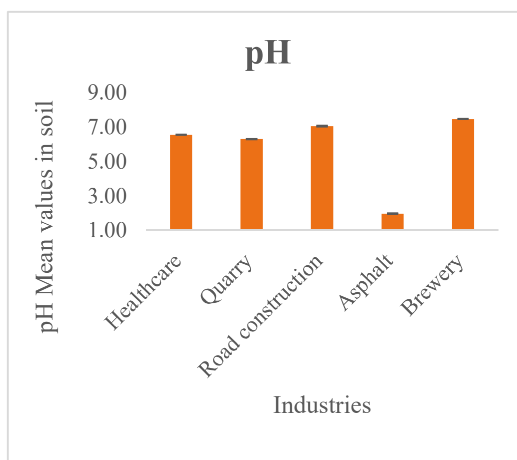

Figure 4. 4 (vi): Mean pH of soil with vertical error bars.

4.1.7 Results of heavy metals' analyses of leaf samples of *Manihot esculenta* and *Carica papaya* plants near selected industries, South Eastern Nigeria.

4.1.7.1 Results of heavy metals' analyses of leaf samples of *Manihot esculenta*.

The mean values of heavy metal analyses of leaf samples of *Manihot esculenta* near studied industries are shown in Table 4.5a. The mean values of lead, in all the industries studied: healthcare (0.040±0.01 mg/kg^{d}); quarry (0.090±0.02 mg/kg^{f}); road construction (0.06±0.002 mg/kg^{e}); asphalt (0.01±0.00 mg/kg^{a,b,c}) and brewery (0.01±0.00 mg/kg^{a,b}) industries, were significantly different ($p<0.05$) from their controls. For cadmium, the mean values in healthcare (0.01±0.00 mg/kg^{a}); quarry (0.01±0.00 mg/kg^{a}); road construction (0.00±0.00 mg/kg^{a}) and brewery (0.01±0.00 mg/kg^{a}) industries, were not significantly different ($p>0.05$) from their controls, while the mean values (0.02±0.01 mg/kg^{b}) in asphalt industry, was significantly different ($p<0.05$) from the control (0.005±0.003 mg/kg^{a}). For mercury, the mean values in healthcare (0.02±0.00 mg/kg^{a}); road construction (0.02±0.00 mg/kg^{a}); asphalt (0.03±0.00 mg/kg^{a}) and brewery (0.01±0.00 mg/kg^{a}) industries, were not significantly different ($p<0.05$) from their controls, while the mean value (0.08±0.03 mg/kg^{b}) of mercury from samples near quarry industry was significantly different ($p<0.05$) from the control (0.01±0.00 mg/kg^{a}). For arsenic, the mean value (0.00±0.00 mg/kg^{a}) of arsenic in quarry industry, was not significantly different ($p>0.05$) from the control (0.00±0.00 mg/kg^{a}), while the mean values of arsenic from samples near healthcare (0.00±0.00mg/kg^{b}); road construction (0.00±0.00mg/kg^{b}) asphalt (0.01±0.00mg/kg^{c}) and brewery (0.00±0.00 mg/kg^{b}) industries, were significantly different ($p<0.05$) from their controls. For chromium, the mean values in healthcare (0.00±0.00 mg/kg^{a}); road construction (0.00±0.00 mg/kg^{a}) and brewery (0.00±0.00 mg/kg^{a}) industries, were not significantly different ($p>0.05$) from their controls, while the mean values in quarry (0.02±0.01mg/kg^{c}) and asphalt (0.01±0.00mg/kg^{b}) industries, were significantly different ($p>0.05$) from their controls.

Table 4.5a: Heavy metals' analyses in leaf samples of *Manihot esculenta* near some industries in South-Eastern Nigeria

Parameters	Healthcare		Quarry		Road construction		Asphalt		Brewery		
	Manihot esculenta Average	Control *Manihot esculenta*	*Manihot esculenta* Average	Control *Manihot esculenta*	*Manihot esculenta* Average	Control *Manihot esculenta*	*Manihot esculenta* Average	Control *Manihot esculenta*	*Manihot esculenta* Average	*Manihot esculenta* Control	Codex Standard (2010)
Lead (mg/kg)	0.04 ± 0.01^{d}	$0.02 \pm 0.01^{b,c}$	0.09 ± 0.02^{f}	$0.01 \pm 0.00^{a,b}$	0.06 ± 0.00^{e}	0.03 ± 0.00^{c}	$0.01 \pm 0.00^{a,b,c}$	$0.01 \pm 0.00^{a,b}$	$0.01 \pm 0.00^{a,b}$	NA	0.3
Cadmium (mg/kg)	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	NA	0.01 ± 0.00^{a}	0.02 ± 0.01^{b}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	0.2
Mercury (mg/kg)	0.02 ± 0.00^{a}	0.01 ± 0.00^{a}	0.08 ± 0.03^{b}	0.01 ± 0.00^{a}	0.02 ± 0.00^{a}	0.01 ± 0.00^{a}	0.03 ± 0.00^{a}	0.01 ± 0.01^{a}	0.01 ± 0.00^{a}	0.01 ± 0.01^{a}	NS
Arsenic (mg/kg)	NA	NA	NA	NA	NA	NA	0.01 ± 0.00^{c}	NA	NA	NA	NS
Chromium (mg/kg)	NA	NA	0.02 ± 0.00^{c}	NA	NA	NA	0.01 ± 0.00^{b}	NA	NA	NA	NS

Legend: NS - None specified, mg/kg - milligram per killogram. *Values with the same superscript across rows are not significantly different ($p>0.05$)*

4.1.7.2 Results of heavy metals' analyses of leaf samples of *Carica papaya*

The mean values of heavy metal analysis of leaf samples of *Carica papaya* near some industries are shown in Table 4.5b. The mean values of lead, in all the industries studied: healthcare (0.03±0.00 mg/kg^{b}); quarry (0.44±0.01 mg/kg^{d}); road construction (0.03±0.01 mg/kg^{b}); asphalt (0.06±0.00 mg/kg^{c}) and brewery (0.04±0.00 mg/kg^{b}) industries, were significantly different ($p<0.05$) from their controls. For cadmium, the mean values in healthcare (0.01±0.00 mg/kg^{a}); road construction (0.01±0.00 mg/kg^{a}); asphalt (0.01±0.00 mg/kg^{a}) and brewery (0.01±0.00 mg/kg^{a}) industries, were not significantly different ($p>0.05$) from their controls, while the mean value (0.02.00mg/kg^{b}) of quarry industry, was significantly different ($p<0.05$) from the control (0.01±0.00 mg/kg^{a}). The mean values of mercury in all the industries studied: healthcare (0.01±0.00 mg/kg^{a}); quarry (0.02±0.00 mg/kg^{b}); road construction (0.01±0.01 mg/kg^{a,b}); asphalt (0.02±0.01 mg/kg^{a,b}) and brewery (0.01±0.01 mg/kg^{a,b}) industries, were significantly different ($p<0.05$) from their controls. The mean values of arsenic in all the industries studied: healthcare (0.00±0.00 mg/kg^{b}); quarry (0.00±0.00 mg/kg^{a}); road construction (0.00±0.00 mg/kg^{b}); asphalt (0.00±0.00 mg/kg^{c}) and brewery (0.00±0.00mg/kg^{b}) industries, were not significantly different ($p>0.05$) from their controls. For chromium, the mean values in all the industries studied: healthcare (0.00±0.00 mg/kg^{a}); quarry (0.02±0.01 mg/kg^{d}); road construction (0.01±0.00 mg/kg^{b,c,d}); asphalt (0.01±0.01 mg/kg^{b,c,d}) and brewery (0.01±0.00 mg/kg^{a,b,c}) industries, were significantly different ($p<0.05$) from their controls.

Table 4.5b: Heavy metals in leaf samples of *Carica papaya* near some industries in South-Eastern Nigeria

	Healthcare		Quarry		Road construction		Asphalt		Brewery		
Parameters	*Carica papaya* Average	Control *Carica papaya*	*Carica papaya* Average	Control *Carica papaya*	*Carica papaya* Average	Control *Carica papaya*	*Carica papaya* Average	Control *Carica papaya*	Carica *papaya* Average	Control *Carica papaya*	Codex Standard (2010)
Lead (mg/kg)	0.03 ± 0.00^{b}	0.01 ± 0.00^{a}	0.44 ± 0.01^{d}	0.04 ± 0.00^{b}	0.03 ± 0.01^{b}	0.02 ± 0.00^{a}	0.06 ± 0.00^{c}	0.01 ± 0.00^{a}	0.04 ± 0.00^{b}	0.01 ± 0.00^{a}	0.3
Cadmium (mg/kg)	0.01 ± 0.00^{a}	0.011 ± 0.001^{a}	0.02 ± 0.00^{b}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	0.2
Mercury (mg/kg)	0.01 ± 0.00^{a}	0.01 ± 0.00^{b}	0.02 ± 0.00^{b}	$0.01\pm0.01^{a,b}$	$0.01\pm0.01^{a,b}$	0.01 ± 0.00^{b}	$0.02\pm0.01^{a,b}$	0.01 ± 0.00^{b}	$0.01\pm0.01^{a,b}$	0.01 ± 0.00^{a}	NS
Arsenic (mg/kg)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Chromium (mg/kg)	NS	NS	0.02 ± 0.01^{d}	$0.01\pm0.00^{c,d}$	$0.01\pm0.00^{b,c,d}$	$0.01\pm0.00^{c,d}$	$0.01\pm0.01^{b,c,d}$	$0.01\pm0.00^{c,d}$	$0.01\pm0.00^{a,b,c}$	NS	NS

Legend: NS - None specified, mg/kg - milligram per killogram. Values with the same superscript across rows are not significantly different ($p>0.05$)

4.1.8. Results of proximate analyses of leaf samples of *Manihot esculenta* near selected industries, South-Eastern Nigeria.

Mean values of proximate analysis of leaf samples of *Manihot esculenta* near some industries were shown in Table 4.6a. The mean values of the moisture content of *Manihot esculenta* in all the industries studied: healthcare (59.70±2.65%^{b}); quarry (66.10±0.10%^{e}); road construction (70.64±0.43%^{f}); asphalt (59.99±5.04%^{d}) and brewery (62.30±0.20%^{d}) industries, were significantly different ($p<0.05$) from their controls. *Manihot esculenta* collected near road construction industry recorded peak values of moisture content (70.64±0.43%), as well as fibre content (5.13±0.03%). The least mean values of moisture content (59.70±2.65%) and lipid content (2.33±0.01%) were recorded from samples near healthcare industry. For ash content, of *Manihot esculenta* in all the industries studied: healthcare (9.04±1.01%^{c}); quarry (14.00±2.65%^{d}); road construction (8.00±3.61%^{b}); asphalt (6.88±1.65%^{b}) and brewery (7.83±0.03%^{b}) industries, were significantly different ($p<0.05$) from their controls. Quarry, Ishiagu had the peak value (14.0±2.65%) of ash content while the least value (6.88±1.65%) was recorded from samples near asphalt, Enugu.

The crude protein content of *Manihot esculenta* mean values in all the industries studied: healthcare (10.07±0.01%^{e}); quarry (6.65±1.01%^{b}); road construction (8.65±0.06%^{c}); asphalt (8.45±0.01%^{c}) and brewery (8.77±0.02%^{c}) industries, were significantly different ($p<0.05$) from their controls. The peak values of crude protein (10.07±0.01%) was recorded from samples near the healthcare industry, Owerri. The sample near the quarry, Ishiagu had the least value (6.65±8.43%) of crude protein. For crude lipid content, the mean values in all the industries studied: healthcare (2.33±0.01%^{c}); quarry industry (3.19±0.01%^{d}); road construction (2.68±0.04%^{c}); asphalt (3.43±0.03%^{e}) and brewery (3.81±0.01%^{f}) industries, were significantly different ($p<0.05$) from their controls. The peak value of lipid content (3.81±0.01%) was recorded from sample near the brewery, Awo-omamma, while samples collected near the healthcare industry, Owerri recorded the least value (2.33±0.01%). For crude fibre content, the mean values in all the industries studied: healthcare (3.61±0.04%[c]); quarry (0.44±0.19%[e]); road construction (5.13±0.15%[d]); asphalt (0.39±0.02%[a]) and brewery (3.20±0.38%[f]) industries, were significantly different ($p<0.05$) from their controls. The mean value (4.90±0.85%[a]) of carbohydrate content, from the road construction industry, was not significantly different ($p>0.05$) from the control (5.34±0.01%[a]), while the mean values from healthcare (15.25±1.74%[d]); quarry (9.62±0.05%[b]); asphalt (20.86±0.04%[c]) and brewery (14.09±0.01%[c]) industries, were significantly different ($p<0.05$) from their controls. The peak values (20.86±0.03%) of carbohydrate content was recorded in asphalt industry, Enugu, while sample near road construction, Owerri, had the least values (4.90±8.60%). The average parameters of proximate analysis, with vertical error bars, for the *Manihot esculenta* in the industries studied, were shown in Figure 4.6 (i) to Figure 4.6 (vi).

Table 4.6a: Results of proximate analyses of *Manihot esculenta* near some industries in South-Eastern Nigeria

Parameters	Healthcare		Quarry		Road construction		Asphalt		Brewery	
	Manihot esculenta Average	Control *Manihot esculenta*	*Manihot esculenta* Average	Control *Manihot esculenta*	*Manihot esculenta* Average	Control *Manihot esculenta*	*Manihot esculenta* Average	Control *Manihot esculenta*	*Manihot esculenta* Average	Control *Manihot esculenta*
Moisture content (%)	59.70 ± 2.65^{d}	22.85 ± 0.05^{a}	66.10 ± 0.10^{e}	32.85 ± 0.03^{b}	70.64 ± 0.43^{f}	62.85 ± 0.04^{d}	59.99 ± 5.04^{d}	42.85 ± 0.05^{c}	62.30 ± 0.20^{d}	66.85 ± 0.01^{e}
Ash Content (%)	9.04 ± 1.01^{c}	2.80 ± 0.10^{a}	14.00 ± 2.65^{d}	5.80 ± 0.10^{b}	8.00 ± 3.61^{b}	2.80 ± 0.10^{a}	6.88 ± 1.65^{b}	2.10 ± 0.10^{a}	7.83 ± 0.03^{b}	2.80 ± 0.10^{a}
Crude Protein Content (%)	10.07 ± 0.01^{d}	6.4 ± 0.40^{b}	6.65 ± 1.01^{b}	6.40 ± 0.20^{b}	8.65 ± 0.06^{c}	6.20 ± 0.20^{b}	8.45 ± 0.01^{c}	2.80 ± 0.10^{a}	8.77 ± 0.02^{c}	2.40 ± 0.10^{a}
Crude Lipid Content (%)	2.33 ± 0.01^{c}	0.20 ± 0.10^{a}	3.19 ± 0.01^{d}	0.20 ± 0.10^{a}	2.68 ± 0.04^{c}	4.20 ± 0.10^{g}	3.43 ± 0.03^{e}	0.21 ± 0.01^{a}	3.81 ± 0.01^{f}	3.20 ± 0.10^{d}
Crude Fibre Content (%)	3.61 ± 0.05^{c}	0.41 ± 0.01^{a}	0.44 ± 0.02^{e}	0.41 ± 0.01^{a}	5.13 ± 0.03^{d}	0.41 ± 0.01^{a}	0.39 ± 0.03^{a}	6.40 ± 0.20^{e}	3.20 ± 0.00^{b}	0.41 ± 0.01^{a}
Carbohydrate Content (%)	15.25 ± 1.74^{d}	50.34 ± 0.01^{g}	9.62 ± 0.05^{b}	5.34 ± 0.01^{a}	4.90 ± 0.85^{a}	5.34 ± 0.01^{a}	20.86 ± 0.04^{e}	30.34 ± 0.01^{f}	14.09 ± 0.01^{c}	20.34 ± 0.02^{e}

Values with the same superscript across rows are not significantly different ($p>0.05$)

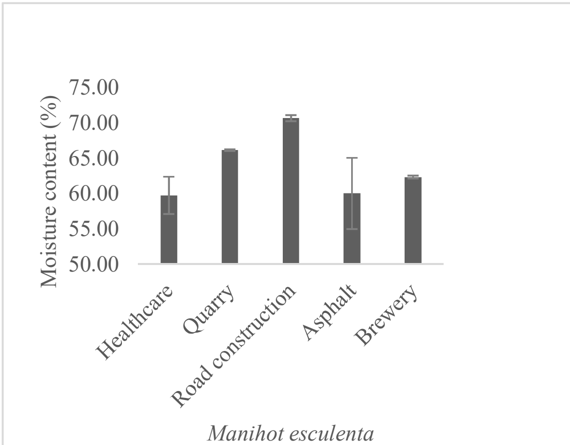

Figure 4.6 (i): Moisture content of *Manihot esculenta* with vertical error bars in selected industries.

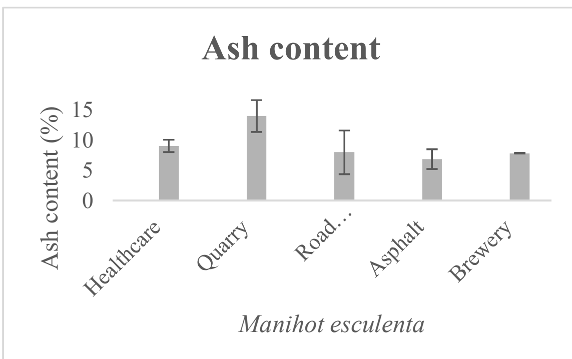

Figure 4.6 (ii): Ash content of *Manihot esculenta* with vertical error bars in selected industries

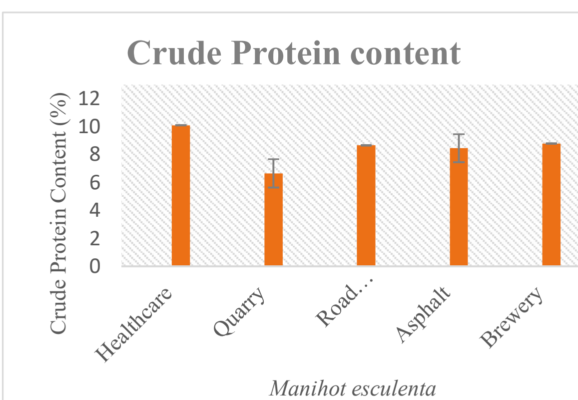

Figure 4.6 (iii): Crude Protein content in *Manihot esculenta* with vertical error bars in selected industries.

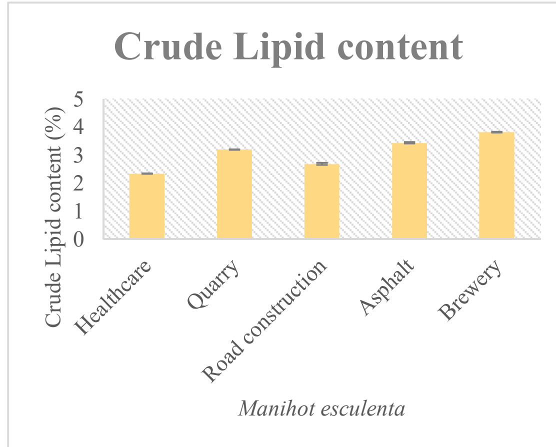

Figure 4.6 (iv): Crude Lipid content of *Manihot esculenta* with vertical error bars in selected industries.

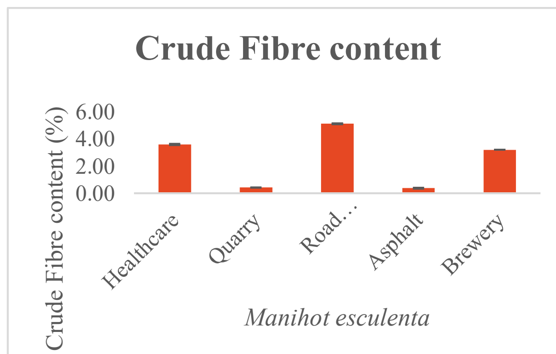

Figure 4.6 (v): Crude Fibre content of *Manihot esculenta* with vertical error bars in selected industries.

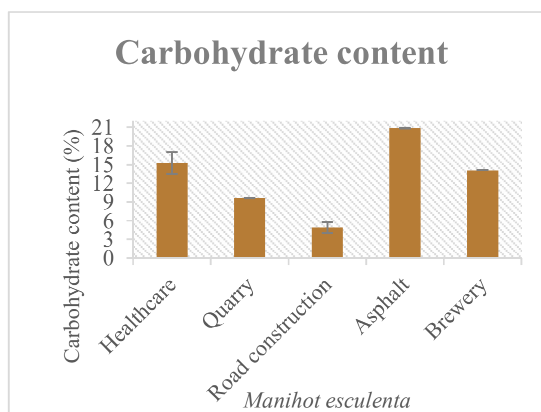

Figure 4.6 (vi): Carbohydrate content of *Manihot esculenta* with vertical error bars in selected industries.

4.1.9 Results of proximate analyses of leaf samples of *Carica papaya* near selected industries, South-Eastern Nigeria.

The mean values of proximate analysis of *Carica papaya* in some industries were shown in Table 4.6b. The mean values of the moisture content of *Carica papaya* in all the industries studied: healthcare (74.8±1.05%^{e}); quarry (74.99±2.45%^{e}); road construction (77.44±0.96%^{f}); asphalt (72.16±0.98%^{d}) and brewery (75.27±0.02%^{e}) industries, were significantly different ($p<0.05$) from their controls. The peak values (77.44±0.96%) of moisture content in *Carica papaya* was recorded from samples near the road construction industry. The leaf samples near the asphalt industry had the least value (72.16±0.98%). Similarly, the ash content of *Carica papaya* in all the industries studied: healthcare (5.96±0.06%^{b,c}); quarry (8.07±0.98%d); road construction (5.53±1.52%^{a,b,c}); asphalt (6.73±1.24%^{c,d}) and brewery (7.64±0.02%^{d}) industries, were significantly different ($p<0.05$) from their controls. Quarry industry, Ishiagu recorded the peak value (8.07±0.98%) of ash content and the least (5.96±0.06%) value was from sample near the healthcare industry.

The crude protein content of *Carica papaya* in healthcare (9.1±0.90%^{b}); quarry (10.59±0.26%^{d}); road construction (8.90±2.15%^{b}); asphalt (11.52±0.91%^{d}) and brewery (8.74±0.02%^{b}) industries, were significantly different ($p<0.05$) from their controls. The peak value (11.52±0.91%) of crude protein were recorded in samples near asphalt, Enugu and the least value (8.74±0.02%) was from sample near the brewery, Awo-omamma. For crude lipid content, the mean values in all the industries studied: healthcare (2.87±0.03%^{c}); quarry (4.37±0.04%^{d,e}); road construction (4.12±1.00%^{d}); asphalt (3.97±0.99%^{d}) and brewery (0.84±0.02%^{b}) industries, were significantly different ($p<0.05$) from their controls. The sample of *Carica papaya* near the road construction industry, had peak value of lipid (412±0.82%) while the sample near brewery recorded the least value (0.84±0.02%). For crude fibre content the mean values in healthcare (4.63±1.07%^{e}); quarry (0.71±0.05%^{b}); road construction

(3.77±0.03%[d]); asphalt (0.44±0.03%[a,b]) and brewery (1.86±0.02%[c]) industries, were significantly different ($p<0.05$) from their controls. The peak (4.63±0.88%) values of fibre content in *Carica papaya* was recorded from samples near the healthcare industry, while samples from the asphalt industry had the least values (0.44±0.03%). The carbohydrate content, mean values in all the industries studied: healthcare (2.64±0.08%[d]); quarry (1.27±0.05%[b]); road construction (1.57±0.01%[c]); asphalt (5.51±0.07%[e]) and brewery (5.65±0.03%[f]) industries, were significantly different ($p<0.05$) from their controls. Carbohydrate contents had peak value (5.65±0.03%) from samples near the brewery, Awo-omamma and the least mean value (1.27±0.04%) was from samples near the healthcare industry. The average parameters of proximate analysis, with vertical error bars, for the *Carica papaya* in the industries studied, were shown in Figure 4.7 (i) to Figure 4.7 (vi).

Table 4.6b: Results of proximate analyses of c*arica papaya* near some industries in South-Eastern Nigeria

	Healthcare		Quarry		Road construction		Asphalt		Brewery	
Parameters	*Carica papaya* Average	Control *Carica papaya*	*Carica papaya* Average	Control *Carica papaya*	*Carica papaya* Average	Control *Carica papaya*	*Carica papaya* Average	Control *Carica papaya*	*Carica papaya* Average	Control *Carica papaya*
Moisture content (%)	74.8 ± 1.05^{e}	14.55 ± 0.02^{a}	74.99 ± 2.45^{e}	64.75 ± 0.01^{b}	77.44 ± 0.96^{f}	74.55 ± 0.03^{e}	72.16 ± 0.98^{d}	64.55 ± 0.04^{b}	75.27 ± 0.02^{e}	70.55 ± 0.05^{c}
Ash Content (%)	$5.96 \pm 0.06^{b,c}$	4.00 ± 0.20^{a}	8.07 ± 0.98^{d}	$4.80 \pm 0.10^{a,b}$	$5.53 \pm 1.52^{a,b,c}$	4.00 ± 0.30^{a}	$6.73 \pm 1.24^{c,d}$	4.00 ± 1.00^{a}	7.64 ± 0.02^{d}	4.00 ± 1.00^{a}
Crude Protein Content (%)	9.1 ± 0.90^{b}	15.60 ± 0.10^{d}	10.59 ± 0.26^{c}	4.00 ± 0.40^{a}	8.90 ± 2.15^{b}	15.60 ± 0.10^{d}	11.52 ± 0.91^{c}	15.60 ± 0.10^{d}	8.74 ± 0.02^{b}	15.60 ± 0.10^{d}
Crude Lipid Content (%)	2.87 ± 0.03^{c}	4.8 ± 0.10^{e}	$4.37 \pm 0.04^{d,e}$	0.02 ± 0.01^{a}	4.12 ± 1.00^{d}	8.48 ± 0.20^{f}	3.97 ± 0.99^{d}	2.80 ± 0.10^{c}	0.84 ± 0.02^{b}	$0.48 \pm 0.01^{a,b}$
Crude Fibre Content (%)	4.63 ± 1.07^{e}	0.03 ± 0.02^{a}	0.71 ± 0.05^{b}	$12.60.02 \pm 0.01^{f}$	3.77 ± 0.03^{d}	0.02 ± 0.01^{a}	$0.44 \pm 0.04^{a,b}$	0.02 ± 0.01^{a}	1.86 ± 0.02^{c}	0.02 ± 0.01^{a}
Carbohydrate Content (%)	2.64 ± 0.08^{d}	16.03 ± 0.01^{i}	1.27 ± 0.05^{b}	1.03 ± 0.01^{a}	1.57 ± 0.01^{c}	1.03 ± 0.01^{a}	5.51 ± 0.07^{e}	6.03 ± 0.02^{g}	5.63 ± 0.03^{f}	10.03 ± 0.01^{h}

Values with the same superscript across rows are not significantly different ($P>0.05$)

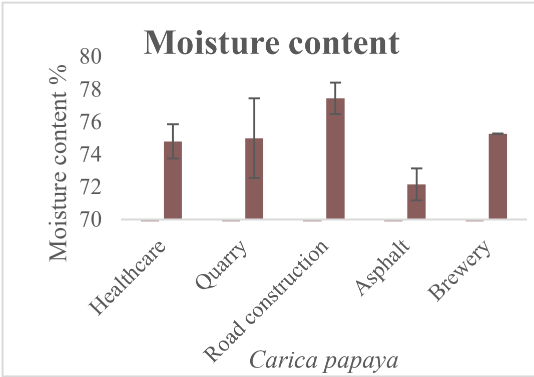

Figure 4.7 (i): Moisture content in *Carica papaya* with vertical error bars in selected industries.

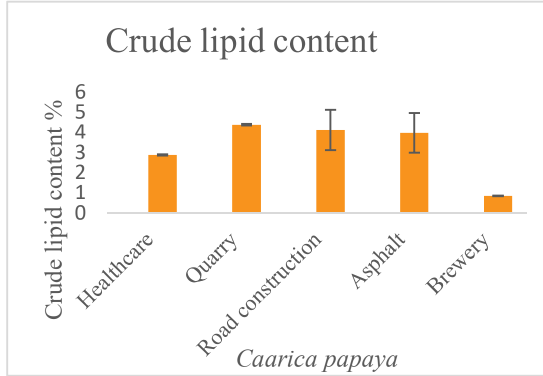

Figure 4.7 (iv): Crude Lipid content in *Carica papaya* with vertical error bars in selected industries.

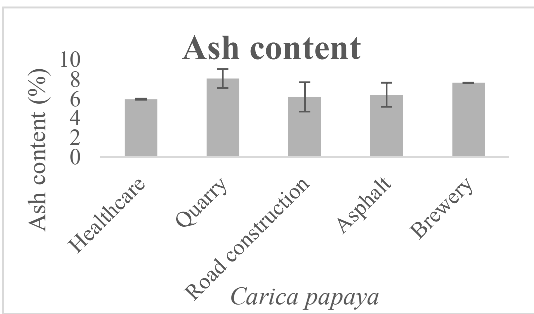

Figure 4.7 (ii) Ash content in *Carica papaya* with vertical error bars in selected industries.

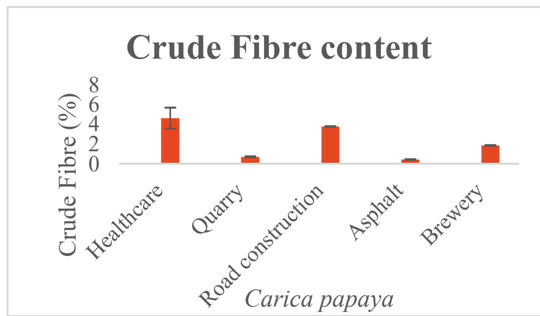

Figure 4.7 (v) Crude Fibre content in *Carica papaya* with vertical error bars in selected industries.

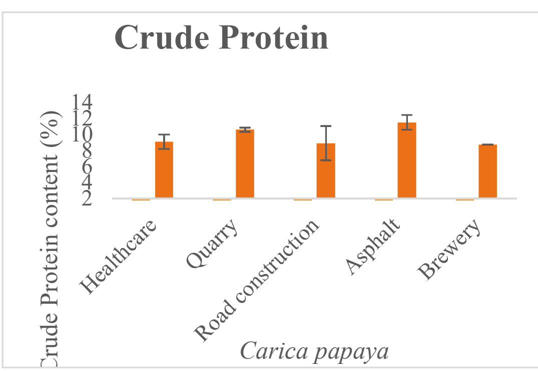

Figure 4.7 (iii): Crude Protein content in *Carica papaya* with vertical error bars in selected industries.

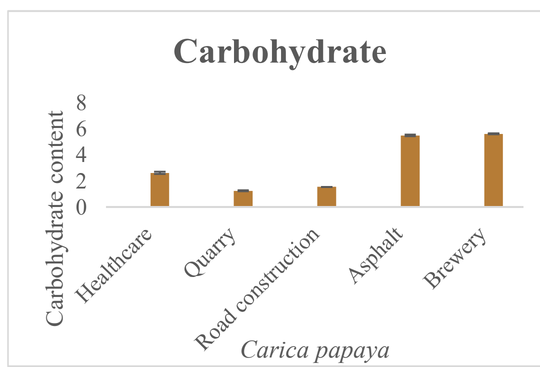

Figure 4.7 (vi): Carbohydrate content in *Carica papaya* with vertical error bars in selected industries.

4.2 Discussion

4.2.1 Demographic data of workers in selected industries.

The occupation of an individual was part of his everyday life, and the nature of the occupation affected the individual's health status. The strategy for age and gender distribution of assessment of health status at the workplace was important and aimed at achieving a sustained reduction of occupational hazards and diseases in South-Eastern Nigeria. Increasing the normal life-span spent at work could contribute to addressing the financial challenges faced by the elderly and productivity levels could rise, and longer work lives could compensate for age-related increases in, health care utilisation. The social, economic and biological determinants and diseases had links with gender to create different health outcomes for males and females but were defined regarding one another. Cabello *et al.* (2015) reported that the different roles of male and female workers in the industry affected the risks of infection.

Exposure of male and female workers to diseases in certain work environments were more pronounced in certain age group and sex. Ostlin (2000) reported that females might suffer more ill-health because they were employed in monotonous and repetitive work and were likely to develop repetitive strain injuries or to be exposed to carcinogenic substances. Males were more often employed in active jobs that involved physically strenuous activities, such as construction, with considerable lifting and moving of heavy loads which expose them to work-related accidents that resulted in death. However, the findings in this research agreed with the findings of Cabello *et al.* 2015, in the area of the infection of the lung, consolidation, which also affected more females (38%) than males (32%). Incidentally, in the brewery industry, only the female workers, within the age group 21-30 and 51 -60 were infected with the consolidation of the lung.

4.2.2 Health status of workers in selected industries.

On auscultation of the chest for the client that had consolidation of the lung, there was increased pectoriloquy while breath sounds decreased, Springer (2016) had similar report. The 'cardiothoracic ratio' (CTR) which showed the measurement on the posterior-anterior chest x-ray, showed the ratio of maximal horizontal cardiac diameter to maximal horizontal thoracic diameter (inner edge of ribs/edge of pleura). The road construction male workers had peak value of 0.45±0.05cm while the control group had mean value of 0.35±0. The transverse cardiac diameter (TCD) mean value was highest (15.38±0.08cm) in a healthcare male worker, and the diagonal measurement from the midpoint of left main bronchus to the right border of the left atrium was greater than 7 cm (convex left atrial appendage) which was normally flat or slightly concave. The male worker was unduly exposed to chemicals used for embalmment. Embalmment fluid comprised of a mixture of formaldehyde, glutaraldehyde, methanol, humectants, and wetting agents.

Research carried out by Takeshita *et al.* (2008) on 'Effects of Formaldehyde on Cardiovascular System Rat Hearts In-Situ' discovered that hearts showed significant decreases in heart rate, cardiac output and in left ventricular end-systolic pressure (ESP), which was a sign of acute left ventricular failure. The pulmonary blood vessel was not dilated and was seen to run its course on lateral chest radiograph superiorly and posteriorly relative to the right while the ascending aorta was obscured by the main pulmonary artery and both atria. The CTR of the workers within the age group 51-60 years appeared larger because of decreasing lung compliance but had a diameter less than or equal to half the transverse diameter of the chest on both posterior-anterior and lateral views of the chest radiograph which showed the absence of obvious cardiac pathology.

The research by Esmail *et al.* (2016) on 'Cardio-Thoracic Ratio as a Screening Tool for HIV-1 Related Cardiac Disorders in Resource-Poor Settings' found Cardiothoracic ratio on chest radiograph as a potential screening tool to identify the cardiovascular disorder in HIV population. In another study by Ogata, et al. (2017) on the research; the cardiothoracic ratio and cardiovascular disease mortality in patients with end-stage renal failure concluded that cardiothoracic ratio was a non-invasive left ventricular hypertrophy index, but its association with cardiovascular disease (CVD) and mortality in hemodialysis (HD) populations was unclear.

The early studies in 1919 on cardiothoracic ratio was carried out by Danzer and after detailed assessment concluded that any measurement above 0.5 or 50% was suspected to result in cardiac pathology. Furthermore the research carried out by Kabala (1987) where Computed Tomography (CT) model was carried out in eight patients showed that the heart diameter and cardiothoracic ratio might change between anterior-posterior chest radiograph, without cardiac failure and heart chamber of 165mm in males and 150mm in females was shown to be the limit between normal and abnormal heart size. Herring (2003) reported that the cardiothoracic ratio separates normal from the abnormal heart and that ratio greater than 50% may still be normal. Increase in the cardiothoracic ratio was observed to be caused by conditions originating from the heart, which include: pectus excavatum deformity, straight back syndrome, inability to take a deep breath like in obesity. Sutton (1988) reported that an upper limit of the cardiothoracic ratio of 55% in black people may still be normal and the ratio may also increase in the elderly which may be due to the infolding ribs that reduce the thoracic component of the ratio in advanced age.

In the research carried out by Murphy (1985) on routine posterior and lateral chest radiograph in 268 patients, to determine heart size compared coronary artery with a specific ventricular mass from a postmortem cardiac partition and concluded that most cases of cardiomegaly can be determined from the chest x-ray. The study by Tomita (2015) on the changes in transverse diameter of the heart on inspiratory and expiratory chest CT with changes in lung size and cardiothoracic ratio, concluded that heart size on chest computed tomography (CT) depended on the phase of ventilation, and was correlated with craniocaudal lung diameter and changes in lung volume. More so, the CTR was significantly influenced by ventilation. In this study, the CTR was correlated with the age of workers, which showed a positive correlation with increasing age except for the healthcare worker that had early exposure period to embalmment chemicals. The measurements of CTR and TCD on chest x-ray were robust and showed a significant difference ($p<0.05$), thereby justified for use in identifying cardiovascular disorder among industrial workers. When two consecutive chest radiographs were taken at short intervals, showed an increase in the transverse cardiac diameter by 1.5cm on the normal upper limits of transverse cardiac diameters of 15.5cm for males and 14.5cm for females, both were considered abnormal, and a sign of cardiomegaly.

The consolidation of the lung occurred in various degrees among the workers in the selected industries and could be associated with volume loss of about 25%, David (2007) had a similar report. Consolidation occurs when the air in the alveoli was replaced with transudate, pus, blood and cells. In this research, the consolidation of the lung was recorded mostly among the female workers. Consolidation of the lung was correlated with the age of workers, which did not show a perfect relationship with increasing age. The predisposing factors of pulmonary consolidation can also cause some degree of collapse. Acute Respiratory Distress Syndrome (like Status Asthmaticus) resulted in an inhomogeneous pattern of lung consolidation. The condition may result from industrial emissions as sources of allergy, exposure to drugs, parasitic infections, or be idiopathic. Clients present with a cough, breathlessness, chronic pulmonary consolidations that may wax and wane. Asthma may be a feature which was also reported by Richard & Kradin (2017). Early in the course of lung injury, heterogeneous changes in lung morphology gave rise to lung zones that consisted of normal lung regions; potentially infectious lung regions within the mid-portion of the lungs; gravity-dependent lung; areas of markedly inflated lung tissue and consolidation. These were equally reported by James, Haenel, Jeffrey & Johnson (2011). Chronic pulmonary consolidations have eosinophilic pneumonia as a differential diagnosis; Richard & Kradin (2017) had a similar report.

Road construction industry workers suffered more consolidation of the lung than the other industries studied. Chest radiology in this study revealed that 71 (7%), healthcare workers had a consolidation of the lung; quarry workers, 130 (13%); road construction workers, 290 (29%); asphalt workers, 118 (12%) and brewery workers, 105 (11%). The correlation of consolidation of the lung with the age of workers in the selected industries showed that the condition was not dependent on increase in age. According to Reagan (1998), inhalation and ingestion of dust showed that absorption from the lung and gut was biologically possible. Therefore, leaded gasoline emissions in dust generated during the road construction contained particles of lead, and its inhalation caused an inflammatory process in the lungs, which gave rise to a condition known as consolidation of the lung. In the research conducted by Laidlaw (2008), in examining the correlation between the lead content in soils of urban roadways in Syracuse, Indianapolis, and New Orleans and the content in soils of corresponding rural areas in the same States, confirmed increased airway risk for those who worked on roads in highly populated areas. Also, research by Echt (2003), on-road construction workers in the South-Eastern

Netherlands, confirmed that road construction and repair workers were potentially exposed to airborne silica dust from activities that created airborne dust, such as sawing, breaking, and grinding of concrete and other materials that contain silica. All these bring a heavy burden on the lung, hence resulted in the consolidation of the lung. More so, the air quality (NO_2, CO_2, CO, SO_2, $TSPM_{10}$) of road construction industry in this study, recorded mean values that were significantly different ($p<0.05$) relative to the control. Particulate matter ($TSPM_{10}\mu g/m^3$) was a complex mixture of organic and inorganic particles, hazardous and suspended in air. The polluted air quality from industries was associated with widespread occupational lung diseases which was also reported by Fulekar (1999).

Chest x-rays serve as an invaluable accessory in the diagnosis and follow-up of tuberculosis (TB). In this study, the radiologic markers in TB involved the pulmonary parenchyma, interstitium, pleura, pericardium, with marked opacities in the upper lobe of the right lung, cavitations, unilateral pleural effusion with hilar lymphadenopathy. TB caused deviation of the mediastinum as well as the trachea. Sputum for *Mycobacterium tuberculosis* tested positive in 5% of the male worker in asphalt industry. TB is caused by bacteria an airborne pathogen, *Mycobacterium tuberculosis* that often affected the lungs. TB can be active or inactive. Active TB is contagious. The asphalt industry worker that was diagnosed with TB can infect up to 10-15 other workers through close contact, which was also reported by McIntosh (2017). TB disease was curable and preventable. According to Jeong *et al.* (2008), primary TB was often clinically silent, but the weak immunity in 5% of infected individuals' resulted to a clinically active disease known as a progressive primary disease.

The post-primary TB resulted when there was decreased immunity, leading to a reactivation of the latent infection. On the CXR it was seen as consolidation with cavitation in the apical segments of the upper and lower lobes. When there was haematogenous spread, miliary TB developed. Another case of post-primary TB with cavity formation in the left upper lobe had widespread ill-defined densities that were likely to be small consolidations and cavity in the right upper lobe. The sputum test was positive for TB. The cavitations in the right upper lobe were taken to be a case of reactivation of a latent TB. Some years later, during the follow-up visitation, the CXR on the right showed, right upper lobe atelectasis, deviation of the trachea, scarring with cavitation of the remnants of the upper lobe and minimal fibrosis. There was cavitation in the left upper lobe with some traction-bronchiectasis due to the fibrosis. McIntosh (2017) reported that TB could be fatal if left untreated. More so, the Centres for Disease Control and Prevention (CDC, 1982) confirmed that TB could be treated since the discovery of TB by Koch's, on March 24, 1882, brought about the development of vaccines and effective drug treatment. The current management of TB led to the belief that the disease was almost defeated. The disease remains a global public health problem. The World Health Organization (WHO, 2018) declared that TB was a global emergency and calls for urgent action to end TB and estimated that there were over five hundred thousand new cases that showed resistance to rifampicin which was the most effective first-line drug to TB, and 82% had multidrug-resistant TB. Early TB diagnosis and prompt treatment with proper compliance, assured good prognosis. The health targets by WHO (2018) of sustainable development goals was to end the TB epidemic by 2030. The TB case in this research was promptly treated, and the CDC was duly notified.

4.2.3.1 Full blood count and erythrocyte sedimentation rate (ESR) of male workers.

The mean values of haemoglobin among quarry, road construction and brewery male workers, were not significantly different (p>0.05) while the mean values of haemoglobin in healthcare and asphalt workers were significantly different (p<0.05) from their controls. The healthcare and asphalt workers within the age groups, 31- 40 and 41-50 years respectively had the moderate limit of haemoglobin and was classified as mild anaemia. Based on the concentrations of haemoglobin in the blood, anaemia was classified as mild, moderate, or severe. For all the tested workers, mild anaemia corresponded to a level of haemoglobin concentration of 10.0 -11.9 g/dl while moderate anaemia corresponded to a level of 7.0-9.9 g/dl. Anaemia was a condition characterised by a decrease in the concentration of haemoglobin in the blood. Haemoglobin necessitated the transport of oxygen to tissues and organs in the body. The reduction in oxygen available to organs and tissues with low haemoglobin levels resulted to various symptoms experienced by anaemic workers. According to WHO (1993), the consequences of anaemia included generalised body weakness and low immunity to disease. The risks of morbidity and mortality increased for anaemic individuals; Sharmanov (1998) had similar findings.

The white blood cell total count (WBC), mean values for the healthcare and quarry workers were not significantly different (p>0.05) while the mean values among the male workers in road construction, asphalt and brewery industries, were significantly different (p<0.05) from the control. The WBC for road construction workers within the age groups 51-60years and asphalt workers, 41-50 years were moderately normal and brewery workers within the age group 21-30 years had high value of normal WBC. In the study carried out by Luo, Hsieh, Chang & Hsu (2002), there was a significantly lower mean white blood cell count in male workers of photolithography, in Taiwan. The origin of white blood cells was in the bone marrow. WBC circulated throughout the bloodstream and was an important part of the immune system. The white blood cell direct count, mean values of neutrophil, basophil and eosinophil in all the industries, were not significantly different ($p>0.05$) from their controls while the average value of lymphocyte in all the industries was significantly different ($p<0.05$) from the control. Lymphocytosis was an indication that the body was dealing with an infection or other stressful condition. Elancheran (2019) reported that lymphocytosis with reactive lymphocytes correlated with acute stress. The average value of monocytes among healthcare, quarry, road construction and brewery male workers were not significantly different ($p>0.05$) from their control, while the mean value among asphalt male workers, was significantly different ($p<0.05$) from the control. Monocytosis often indicated the presence of chronic infection such as tuberculosis or endocarditis as well as rheumatic disorders; an autoimmune or blood disorder, cancer. Previous study by Wiersinga, Leopold & Cranendonk (2014) identified peripheral blood monocytosis as a negative prognostic marker in the emergency setting and reported that activation of the innate immune system often indicated presence of a critical illness.

The mean values of ESR among asphalt male workers was not significantly different ($p>0.05$) from the control while the mean value among healthcare, quarry, road construction, and brewery male workers, were significantly different ($p<0.05$) from the control. The peak value (71.45±20.97 mm/hr.) of erythrocyte sedimentation rate for the male was recorded among quarry workers. Elevated ESR occurred with inflammation, infection, ageing, anaemia and associated with heart failure. The report by Maradit-Kremers *et al.* (2007) suggested that raised ESR was a possible inflammatory marker associated with heart failure in patients with rheumatoid arthritis. The normal range used were as described by Daller (2016) for FBC and ESR Kellner & Wheeler (2014) for ESR.

4.2.3.2 Full blood count and erythrocyte sedimentation rate (ESR) of female workers.

The mean values of haemoglobin among healthcare and quarry, road construction and female brewery workers, were not significantly different ($p>0.05$) from their controls. The mean value of haemoglobin among asphalt female workers was significantly different ($p<0.05$) from the control and the low level affected mostly females; similar findings were reported by Dubey (2013). Out of which 3% were from the road construction industry, in the age group of 51-60 years. Then, 6% were asphalt industrial workers in the age group of 41-60 years and 5% from brewery industries in the age group of 21-30years, relative to the control subjects. Anaemia can be classified as mild anaemia using the WHO (2011) Public health significance of anaemia blood levels of haemoglobin 5.0 – 19.9% was classified as mild anaemia. Some studies by WHO, UNICEF, UNU, (2001) suggested that capillary samples of haemoglobin values were higher than that of venous samples. If the haemoglobin level recorded was lower than normal (Male: 14-18g/dl, Female: 12-16g/dl), the worker was said to be anaemic. The link between anaemia and heart disease is clear according to Ravish, (2013): Up to 48 per cent of people who had heart failure are anaemic. Anaemia was a deficiency in the number or quality of red blood cells which has the oxygen-carrying capacity, using a protein known as haemoglobin to circulate oxygenated blood around the body. The reduction in the number of red blood cells (and consequently their oxygen-carrying capacity) was insufficient for the physiologic needs of the body which vary with a person's age, gender, and residential elevation above sea level. Anaemia resulted from iron deficiency, nutritional deficiencies (including folate, vitamin B_{12}, and vitamin A), acute and chronic inflammatory conditions, parasitic infections, and inherited or acquired disorders that affected haemoglobin synthesis and survival. According to WHO/CDC (2007), the prevalence of anaemia was an important health indicator.

WBC count was usually measured to determine the presence of an infectious process. and range between 4,500-10,000mcl. The mean values for the white blood cell total count, among the female workers in quarry, road construction, and female brewery workers, were not significantly different ($p>0.05$) from their controls while the mean values among the female workers in healthcare and asphalt, were significantly different ($p<0.05$) from their controls. The mean values of WBC, count among the female workers in healthcare was raised while the level was lower among asphalt industry female workers relative to the control. A low or high white blood cells count may have an underlying blood disorder or other medical condition. A low count referred to as leucopenia can be triggered by severe infections, autoimmune disorders, bone marrow damage, some medications, such as antibiotics. The study by Okpako & Berewari (2014) suggested that leukopenia was a potential health effect of industrial hazards. Leukocytosis resulted in coronary heart disease through multiple pathologic inflammatory processes caused protolithic and oxidative damage to the endothelial cells occluding the microvasculature, induced hypercoagulability, and promoted infarct expansion. Hung & Cherng (2003) reported that the prognosis of cardiovascular diseases had been dependent on the level of the leukocyte as a predisposing factor. The low levels of white blood cells compared to the control, affected 3% of road construction workers and 5% of asphalt workers, both within the age group 51- 60 years.

There were several types of white blood cells: neutrophils, lymphocytes, eosinophils, monocytes, and basophils. For the mean values of white blood cell direct count neutrophil, lymphocyte, basophil and eosinophil in all the industries, were not significantly different ($p>0.05$) from their controls. The mean values of monocytes, among healthcare, quarry, road construction and female brewery workers, were not significantly different ($p>0.05$) from their controls while the mean value of monocytes among asphalt female workers was significantly different ($p<0.05$) from the control. The differential count was normal except the eosinophil that was raised in different age groups among female industrial workers relative to the control subjects. The high levels of eosinophils was a possible biomarker and an inflammatory marker that had been implicated in coronary heart disease, especially where the radiology reports revealed cardiovascular disease. The study carried out by AbdElhamid *et al.* (2017) on the assessment of allergy marker leucocyte (eosinophil) count and other blood cells parameters among workers at Berber cement factory, Sudan, showed that allergy marker eosinophils were increased while other blood cell parameters were not affected which showed intimate relation between exposure to cement dust and eosinophilia. The study by, Madjid, Awan, Willerson, & Casscells (2004) on elevated differential cell counts, including, eosinophils, monocytes, and neutrophils, predict the incidence of coronary heart disease.

The basophil count was raised only in 3% of road construction workers. Basophils have some role in immune surveillance, release histamine and other mediators and play a role in the initiation of allergic reactions and wound repair. Basophilia can occur in hypothyroidism, hyperlipidemia, tuberculosis, polycythemia vera, and myelofibrosis. In the study by Lucijanic *et al.* (2018) on high absolute basophil count was a powerful independent predictor of inferior overall survival in patients with primary myelofibrosis. The high absolute basophil count reflected higher disease activity and stronger proliferative potential and poor prognosis. Previous study revealed that some lifestyle changes, such as increasing exercise may help reduce the risk of inflammation and lower adverse health effects. The industrial pollution affected the health of workers who did not use personal protective equipment regularly and the work environment where safety measures were neglected. Johannsen *et al.* (2012) reported that there was reduction in total WBC and neutrophil counts in overweight/obese postmenopausal women after six months of aerobic exercise training in a dose-dependent manner and most beneficial to patients with low-grade inflammation.

The mean values of erythrocyte sedimentation rate in healthcare, quarry, road construction, asphalt and brewery female workers, were significantly different ($p<0.05$) from the control. The peak value of erythrocyte sedimentation rate for the female was recorded among road construction workers. The elevation in erythrocyte sedimentation rate from the five industries were possible inflammatory biomarkers. In the study conducted by Bitik et al. (2015) 'Differential diagnosis of elevated erythrocyte sedimentation rate and C-reactive protein levels: a rheumatology perspective' found out that in the general population, the common aetiology of nonspecific elevations in erythrocyte sedimentation rate levels was as a result of new-onset Rheumatoid disease. Yousuf, Akhter, Al-Khairy, Al-Saadan, & Bin-Salih (2010) conducted a study in 'Extremely elevated erythrocyte sedimentation rate aetiology at a tertiary care centre in Saudi Arabia' and concluded that the patients with extreme erythrocyte sedimentation rate elevation had an underlying aetiology.

ANOVA ($p<0.05$) revealed significant difference in the mean concentrations of the measured parameters in health status: cardiothoracic ratio and the transverse cardiac diameter; consolidation of the lung and the full-blood count, relative to that of the control.

4.2.4.1 Heavy metal analyses on the hair of workers

The mean values of lead recorded among healthcare, brewery and asphalt industries, were not significantly different ($p>0.05$) from their controls while the mean values recorded among workers in quarry and road construction industries, were significantly different ($p<0.05$) from their controls. The heavy metal presence on hair could be from leaded gasoline used in road construction and from quarry dust. Reagan (1998), reported that leaded gasoline produced 90% of air emission in the 1970s, and was, therefore, a major source of contamination in the environment. Reagan also examined data from soil samples taken from sites along U.S. roadsides and found inordinately high levels of lead residue. The work was done in several locations to show consistent findings. High levels of lead were also recorded by Eruyogho, Okuo & Ndiokwere (2007) in a case study on levels of some heavy metals in the scalp of urban dwellers. The mean values of cadmium recorded among workers in the quarry, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls. The mean values of cadmium recorded among workers in the healthcare industry, was significantly different ($p<0.05$) from the control. The peak value of cadmium (0.79 ± 0.03 mg/l) was recorded among healthcare workers in this study. The level of cadmium may have resulted from the incineration of electronic waste carried out within the premises. There was no cadmium recorded among workers in brewery industry, Awo-omamma. The research conducted by WHO (2007) confirmed that cadmium was released into the environment from human activities such as the use of cadmium-containing batteries and phosphate fertilizers, incineration of electronic wastes and tobacco smoking, also reported by Manno (2010). Cadmium was mainly absorbed by inhalation. A study carried out by Aliomrani *et al.* (2016) on the concentrations of cadmium and lead among hospitalized multiple sclerosis patients showed high values of lead and cadmium in blood samples examined. A similar study by González-Estecha (2009) in a six-hospital employee population, on blood lead and cadmium levels revealed low blood levels of lead and cadmium. The mean values of mercury among workers in healthcare, quarry, road construction, and asphalt were not significantly different ($p>0.05$) from their controls. The mean value of mercury among workers in the brewery was, significantly different ($p<0.05$) from the control. The peak value of mercury was recorded among the brewery workers (0.20±0.10mg/l) but least value among the quarry workers (0.01±0.10mg/l). Arsenic mean values in healthcare, quarry, road construction, and asphalt were not significantly different ($p>0.05$) from their controls. The mean values of arsenic among workers in the brewery was, significantly different ($p<0.05$) from the control. The mean values of arsenic in all the industries studied were within FMEnv Standard (1991).The mean value of chromium among healthcare workers was not significantly different ($p>0.05$) from the control while the mean values of chromium among workers in quarry, road construction, asphalt and brewery industries, were significantly different ($p<0.05$) from their controls. Chromium peak value (0.12±0.01mg/l) was recorded among road construction workers and least (0.02±0.02mg/l) among healthcare workers. The values of Hg, As and Cr, were highest 0.11±0.03mg/l, 0.20±0.01mg/l, and 0.12±0.01mg/l respectively among road construction workers, and the values were above Federal Ministry of Environment Standard limit, 1991. The report of Zehetner, Rosenfellner, Mentler & Gerzabek (2009) confirmed that heavy metals existed in fuels, engines and components of vehicle as well as on-road surface materials, which were suspected sources of the values recorded in this study. In a related work by Mafuyai, Kamoh, Kangpe, Ayuba, & Eneji (2015) on heavy metals contamination in roadside dust along major traffic roads in Jos Metropolitan Area, Nigeria, showed that the mean concentrations of Arsenic for the entire region was higher than its background value.

The researcher recorded, "i hair" in alopecia areata on a 24-year-old brewery staff who ignored the use of personal protective equipment (PPE). The job categories of this brewery worker included cleaning up chemical spills and leaks, cleaning equipment, mixing the chemical, changing solid sources and pump oil, and changing or filling containers for chemicals on machines. Lack of adequate respiratory protection may allow workers to be exposed to haematological toxins, also reported by, Hall (2017). Malakar & Mehta (2017) reported that, in alopecia areata, the inflammatory infiltrates around the lower portion of the anagen hair follicle resulted in black dots which signified residues of pigmented hair destroyed at the level of the scalp. Inui, Nakajima, Nakagawa & Itami (2008) in a research on 'Clinical significance of dermoscopy in alopecia areata: analysis of 300 cases' determine dermoscopic findings of alopecia areata that can be used as clinical indicators of disease and concluded that black dots, tapering hairs, broken hairs, yellow dots, and clustered short vellus hairs, were useful clinical indicators. Malakar, Mehta & Malakar (2017) carried out a research on "i hair": A prognostic marker in alopecia areata & trichotillomania, discovered that the use of a trichoscopy had unveiled a plethora of signs which helped in decoding the underlying microscopic condition of hair and acted as prognostic markers that revealed the trichoscopic sign, "i hair" in alopecia areata. Also, Rudnicka *et al.* (2008) on a research on 'Trichoscopy, a new method for diagnosing hair loss carried out videodermoscopy of hair and scalp (trichoscopy) a valuable tool in differential diagnosis of hair loss which showed that the black dots in alopecia areata revealed dysmorphic hair shafts with damage to the hair follicle.

4.2.3 Air quality assessment in selected industries in South-Eastern Nigeria

The mean values of NO_2 in healthcare and brewery industries were not significantly different ($p>0.05$) from their controls, while the mean values of NO_2 in the quarry, road construction and asphalt industries, were significantly different ($p<0.05$) from their controls. The mean values of NO_2 were above NESREA (1991) standard. In quarry and asphalt industries, the mean values of CO_2 were not significantly different ($p<0.05$) from their controls but were significantly different ($p<0.05$) from the controls in healthcare, road construction and brewery industries. The mean values of CO_2 were above NESREA (1991) standard in the industries studied except in the healthcare industry. Carbon (IV) oxide was extremely hazardous gas that can kill either by displacing O_2, leading to rapid asphyxiation or as a toxin in its own right. Exposure to as little as 0.5% volume CO_2 represents a toxic health hazard as was reported by Wilson (2014) on 'CO_2 Gas Hazards in the Brewing Industry' that most tragic circumstances were seen when workers had probably forgotten to fit a yeast plug and had leaned into the tank that was already concentrated with CO_2 to fit one and had been poisoned in seconds. The major limitation of air pollution and carbon management was the lack of data and concentration of major air pollutants in Nigeria. No monitoring station contributed to data on the concentration of CO_2.

The CO, mean values in road construction and brewery industries, were not significantly different ($p>0.05$) from their controls while the mean values in healthcare, quarry and asphalt industries, were significantly different ($p<0.05$) from their controls. However, the mean values of CO in this study, were above NESREA (1991) standard. For SO_2, the in healthcare, quarry, road construction, asphalt and brewery industries, were significantly different ($p<0.05$) from their controls. The mean values of VOCs, in healthcare, quarry, road construction and brewery industries, were not significantly different ($p>0.05$) from their controls while the mean value of VOCs in the asphalt industry was significantly different ($p<0.05$) from the control. However, the mean values of VOCs, in the industries studied, were above NESREA (1991) standard. In healthcare and brewery industries, the mean values of total suspended particulate matter ($TSPM_{10}$) were not significantly different ($p>0.05$) from their controls while the mean values in the quarry, road construction and asphalt industries, were significantly different ($p<0.05$) from their controls.

Air quality as regards to the gases analysed in this study showed that the asphalt industry had mean values well above the NESREA (1991) standard limit, hence, had the poorest air quality. In a research conducted by the National Institute for Occupational Safety and Health

(NIOSH, 2014) it was revealed that there were two main hazards associated with asphalt: fire and explosion hazards, and health hazards associated with inhalation of fumes and vapours. The International Agency for Research on Cancer (IARC, 2013) reported that the asphalt binder was associated with high temperature, which resulted in emissions. These emissions have an impact on the ecosystem and human health.

The research carried out by Ibe, Opara, Njoku, & Alinnor (2017) on 'Ambient Air Quality Assessment of Orlu, Southeastern, Nigeria', concluded that the mean value of PM_{10}, NO_2, and CO in all the air quality monitoring locations exceeded the US National Ambient Air Quality Standard, while SO_2 level was within Nigerian National Ambient Air Quality Standard limit. However, this was contrary to the findings in this research, and the SO_2 mean values were above the NESREA Standard limit in all the industries studied. Nkwocha, Nwokocha & Egejuru, (2008) in an 18-month prospective study to assessed the effects of industrial air pollutants on the respiratory health of children, provided a strong correlation between exposures to four criteria air pollutants, namely CO, NO_2, SO_2, and PM_{10}, and the incidence of bronchitis.

The findings in this research suggests that anthropogenic activities in the industries and adjoining environment resulted in the increased emissions mainly from the use of generators, traffic and industrial effluents and were responsible for the increase in atmospheric pollution levels recorded in air quality. Health effects from industrial air pollutants may be experienced soon after exposure as was recorded with the case of acute respiratory syndrome, status asthmaticus, with the mean values of white blood cell differential count in significantly different ($p<0.05$) from the controls in asphalt industry. The adverse health effects, years after exposure, in the case of latent infection of *mycobacterium tuberculosis* that resulted in active infection in the immuno-compromised worker, also in asphalt industry.

In the air quality assessment, the long error bars showed that the concentration of the values upon which the average was calculated was low and that the average value was uncertain. More so, the short error bars showed that the concentration of values was high, and the average value was definite. ANOVA ($p<0.05$) revealed a significant difference in the mean concentrations of the measured air pollutants: NO_2, CO, CO_2, SO_2, VOCs, TSPM10μg/m³.

4.2.4 Physicochemical and microbial analyses of water in selected industries in South-Eastern, Nigeria.

The mean values of temperature in healthcare, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls, while the mean value in quarry industry was significantly different ($p<0.05$) from the control. The record revealed that the temperature values were between 27.17±0.06°C (in the brewery industry) to 33.20±1.97°C (in the quarry industry). According to the technical report, the United Nations Educational, Scientific and Cultural Organization (UNESCO) temperature increases the rate of chemical reactions, aquatic plants photosynthesis, organisms' metabolic rate and interaction of pollutants with the aquatic ecosystem. For pH, the mean values in healthcare, quarry, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) across rows and with their controls. The pH peak value (8.07±1.73) was recorded in Nworie river near healthcare industry, Owerri while Njaba river near breweries, Awo-omamma had the lowest pH of 6.59±0.76. The technical report by the United Nations Educational, Scientific and Cultural Organization (UNESCO) shows that pH values between 6.5 and 8.5 were the desirable performance of the aquatic ecosystem. At lower pH, metals were usually more toxic as their solubility increased. The mean values for conductivity, in healthcare, quarry, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls. The peak value of conductivity (6262.67±10503.89µS/cm) was recorded in Akpoha river near quarry industry, Ishiagu and least value (16.67±4.71µS/cm) at Njaba river, near brewery industry, Awo-omamma. According to the technical report the United Nations Educational, Scientific and Cultural Organization (UNESCO), electrical conductivity increases when salt, that also make up animal and human wastes dissolve in water and can be used to detect contaminated water. For total dissolved solids, the mean values in healthcare, quarry, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls. The peak value of total dissolved solids (1596.70±2701.40mg/l) was recorded in Nworie river and least value (10.83±3.06 mg/l) in Njaba river. For dissolved oxygen, the mean values in rivers near healthcare, quarry, road construction and brewery industries, were not significantly different ($p>0.05$) from their controls, while the mean value of dissolved oxygen in asphalt industry was significantly different ($p<0.05$) from the control. Dissolved oxygen, peak value (5.07±0.15 mg/l) was recorded at the brewery, Awo-omamma and was least 2.67±1.59 mg/l in the Akpou-ga river near asphalt industry, Enugu.

The mean values for biochemical oxygen demand, in the rivers near quarry, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls, while the mean value in the healthcare and road construction industries, were significantly different ($p<0.05$), from their controls. The peak value (4.40±3.39 mg/l) of biochemical oxygen demand, was recorded in the healthcare industry while the least value (1.60±0.70 mg/l) was recorded in Akpou-ga Nike river near asphalt industry. An important water quality parameter, dissolved oxygen, showed the health of an aquatic ecosystem and was measured at the same time of the day. According to the technical report by UNESCO, the production of oxygen occurrs during photosynthesis of plants only during daylight period and utilised during respiration and decomposition that occurred 24 hours daily. The dissolved oxygen concentrations declined at night and got to the lowest value before dawn. For nitrate (NO_3^-), the mean values in the quarry, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls while the mean value of nitrate in the healthcare industry was significantly different ($p<0.05$) from the control. Nitrate-Nitrogen (NO_3- N), had mean values in the quarry, road construction, asphalt and brewery industries, and were not significantly different ($p>0.05$) from their controls while the mean value in the healthcare industry, was significantly different ($p<0.05$) from the control. The peak value NO_3- N (34.13±45.42) mg/l was recorded in Nworie river near healthcare industry, Owerri while the least value (1.83±1.07 mg/l) was in Akpou-ga Nike river near asphalt industry, Enugu. For phosphate (PO_4^{-3}), the mean values in healthcare, quarry, road construction, asphalt and brewery industries were not significantly different (0.05) from their controls. The peak value of PO_4^{-3}, 14.90±5.35 mg/l was recorded in the healthcare industry, Owerri while the least value (3.67±3.80 mg/l) was in the quarry industry, Ishiagu. For phosphorus (P), the mean values in healthcare, quarry, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls. Phosphorous (P), recorded, had peak value (4.79±1.68 mg/l) in the healthcare industry, Owerri while the least value (1.33±1.10 mg/l) was recorded in the quarry, Ishiagu.

In the analyses of heavy metals, lead (Pb), mean values in healthcare, quarry, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls. Pb recorded the peak value of 1.87±1.92mg/l in Nworie river, which exceeded the control limit and WHO's (2008) Guidelines for Drinking-water Quality. For cadmium (Cd), the mean values in healthcare, quarry, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls. The peak value of cadmium (0.17±0.10 mg/l) was recorded in Nworie river, Owerri. The mean values of mercury (Hg), in healthcare, quarry, road construction and asphalt industries, were not significantly different ($p>0.05$) from their controls, while the mean value of mercury in the brewery industry, was significantly different ($p<0.05$) from the control. Mercury had peak value of 0.14±0.03 mg/l in the Akpoha river near quarry industry, Ishiagu. For arsenic (As), the mean values in healthcare, quarry, road construction, asphalt and brewery industries were not significantly different ($p>0.05$) from the control. However, the peak value of arsenic (0.18±0.23 mg/l) was recorded in Njaba river and exceeded the maximum heavy metal limit by FMEnv. Standard 1991. The mean values of chromium Cr, in healthcare, quarry, road construction, asphalt and brewery industries, were significantly different ($p<0.05$) from their controls. The peak value of Cr (0.12±0.14 mg/l) was recorded, in Nworie river, Owerri and was above WHO's standard. Only Hg had the peak value of 0.14±0.03 mg/l in the Akpoha river near the quarry industry, Ishiagu and exceeded the control limit and the FMEnv. Standard 1991.

Research carried out by Mohod & Dhote (2013) on a review of heavy metals in drinking water and their effect on human health revealed that the levels of heavy metals were more than the maximum admissible and desirable limit by WHO standard. Thus, the result of heavy metal contamination of Nworie river, Owerri was an indication of pollution hazards that may likely have emanated from the high emission of lead (Pb) from the combustion of dredging machine and boat that were regularly used in the river. The Akpoha river near quarry industry, Ishiagu that was polluted with mercury could be as a result of explosives used in quarrying. According to the U.S. EPA, and the International Agency for Research on Cancer (2016), these metals are also classified as possible human carcinogens based on epidemiological and experimental studies showing an association between exposure and cancer incidence in humans. Heavy metal-induced toxicity and carcinogenicity involve many mechanistic aspects, some of which were not elucidated or understood. Among the heavy metals, As, had extensively been studied for its public health effects. Smith, Lingas & Rahman (2000) reported that drinking 1 L/day water with As of 50 µg/L over one's lifetime could lead to cancer of the liver, lung, kidney or bladder in 13 per 1000 persons. Ahsan, Chen, Parvez, Zablotska, & Argos (2006) in the study on arsenic exposure from drinking water and risk of premalignant skin lesions in Bangladesh, reported an increased occurrence of skin lesions from As dose of 0.0012 mg/kg/ day through drinking water. Arain *et al.* (2009) in a related study in the southern part of Pakistan reported a moderate correlation between As in drinking water and central nervous disorder and cognitive development. In a research by Rosado *et al.* (2007) on Arsenic exposure and cognitive performance among Mexican school children, found an accumulation of the metal in the fingernails and hair of the children.

In microbial analysis of water, the mean values of total bacteria count, in healthcare, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls, while the mean value of total bacteria count in the quarry industry, was significantly different ($p<0.05$) from the control. The peak value ($7.3x10^5 \pm 8.1$ CFU/ml) of total bacteria count was recorded in Akpou-ga Nike river near Asphalt industry, Enugu but least ($2.9x10^5 \pm 3.0$ CFU/ml) in Nworie river near healthcare industry, Owerri. The mean values of total petroleum heterotrophic bacteria in healthcare, quarry, road construction and brewery industries, were not significantly different ($p>0.05$) from their controls while the record in the asphalt industry, was significantly different ($p<0.05$) from the control. The peak value of total hydrocarbon utilizing bacterial (HUB) was recorded in Akpou-ga Nike river near the asphalt industry. For total fungi count, the mean values recorded in river near healthcare, quarry, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls. The mean value of the total fungal count had peak value ($3.5x10^5 \pm 6.7$ CFU/ml) recorded in Akpoha river near quarry industry, Ishiagu, and least ($2.0x10^3 \pm 2.6$ CFU/ml) in Akpou-ga Nike river. For total hydrocarbon utilizing fungi (HUF), the mean values recorded in river near healthcare, quarry, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls. The mean values of total petroleum heterotrophic fungi were highest in the quarry industry, and there was no growth in the asphalt industry.

The presence of pathogenic bacteria in the water was sporadic and erratic, and the levels were low. However, safe water demands that it was free from pathogenic bacteria, which was also reported by Cabral (2010). The presence of total petroleum heterotrophic bacteria was reported on chronically polluted sites in this research. Similar report was by the researches of Ekpenyong, Antai & Essien, 2007; Ichor, Okerentugba & Okpokwasili, 2014 on the biodegradation of total petroleum hydrocarbon by aerobic heterotrophic microorganisms, after analysis of crude oil-contaminated water and sediment samples, which resulted in increase in total petroleum heterotrophic bacteria, that could utilize carbon and energy from crude oil. The peak value (3.5×10^5 CFU/ml) of the total fungal count was recorded in Akpoha river near quarry industry, Ishiagu while the least value (2.0×10^3 CFU/ml) was recorded in Akpou-ga Nike river near asphalt industry, Enugu. Microbial communities were quite sensitive to environmental changes; these, of course, had been the reasons for the variations in the industries studied. Chikere & Azubuike (2014) reported on the research; hydrocarbon polluted sediments and water, the characterisation of hydrocarbon utilising fungi that the total petroleum heterotrophic fungi counts increased more than hydrocarbon utilising fungal counts which signified long term pollution. ANOVA ($p<0.05$) analysis showed significant difference in the mean concentrations of the physicochemical properties of measured water parameters.

4.2.5 Physicochemical and microbial analyses of soil in selected industries in, South-Eastern Nigeria.

The soil textural class proportion of sand, silt and clay content in the industries studied on a weight basis, had no definite pattern. According to the classification by the International Union of Soil Sciences (IUSS, 2014), the textural class of the soils studied were identified as sandy and loamy sand soils. Although sandy soils were consistently recorded. The industries studied had more clay than sand except in the asphalt industry, where there was more silt than clay. Due to the favourable combination of large surface area and smaller pores, clay particles had high water- and nutrient-holding capacity. It also, participate in chemical reactions in the soil as was reported by Osman (2013). The quarry and asphalt industry soil were sandy soils. Sandy soils were loose and had larger pores which could accommodate air and absorb water rapidly but had little or no capacity to hold water or nutrients and tend to remain dry. In this research, the textural class of these industrial sandy soils also had low percentage of clay and recorded no growth of total petroleum heterotrophic bacteria, and total fungi count was zero. The other industries healthcare, road construction and brewery had loamy sand soils and good percentage of clay and grew microorganisms. The growth of microorganisms by loamy sand soils also agreed with the findings of Osman (2013), that the coarseness or fineness of soil determined its air-water relationships and also influences other soil characteristics and microorganisms.

The soil porosity showed the movement of air, water, and the drainage of excess water. The mean values of soil porosity was higher in cultivated soil around the brewery industry (52.00±2.00%); lower in the swamps (32.00±2.65%) around the road construction industry and lowest in the built-up areas of the healthcare industry (28.00±1.53%). The findings in this study corresponded to the findings of Uquetan *et al.* (2017) in the research on the evaluation of soil quality with land use. The mean values of pH in healthcare, quarry, road construction, asphalt and brewery industries, were significantly different ($p<0.05$) from their controls. The mean values of pH in the asphalt industry, Enugu was highly (1.96±0.02) acidic and was basic (7.45±0.01) in the brewery industry, Awo-ommama which was above FMEnv. Standard (1991) limit of 6.5. However, the findings of this study were contrasting with the findings of Kida & Kawahigashi (2015) on the influence of construction processes of asphalt pavement on urban soil discovered that mineral soils underneath the pavements had high pH values.

The absorption of nutrients, minerals and growth of plants was affected by the acidity and alkalinity of the soil. The soil pH of 6.5 promoted the availability of plant nutrients. For lead, the mean values in healthcare, quarry, road construction, asphalt, and brewery industries, were significantly different ($p<0.05$) from their controls and were above FMEnv. Standard (1991) limit of 0.05mg/kg. For cadmium, the mean values in healthcare, quarry, road construction, asphalt, and brewery industries, were significantly different ($p<0.05$) from their controls. However, the mean values of cadmium in healthcare, road construction and brewery industries, were above FMEnv. Standard (1991) limit of 0.01 mg/kg. For mercury, the mean values in healthcare, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls while the mean value of mercury in quarry industry was significantly different ($p<0.05$) from the control. The mean values in healthcare, quarry, road construction, asphalt, and brewery industries, were above FMEnv. Standard (1991) limit of 0.02 mg/kg. For arsenic, the mean values in healthcare, quarry, road construction, and asphalt industries, were not significantly different ($p>0.05$) from their controls while the mean value of arsenic in the brewery industry was significantly different ($p<0.05$) from the control. Arsenic mean values were low in the samples studied, except in samples from the healthcare (0.28±0.01 mg/kg) industry, Owerri and exceeded FMEnv. Standard (1991) limit of 0.05mg/kg. Incineration of various types of waste, including medical waste, hazardous waste, as well as internal combustion, were possibly the sources of arsenic in the healthcare industry.

The arsenic content of hazardous waste varied widely, and substantial quantity could be emitted from the incineration of the medical waste and hazardous waste, mentioned above. On research carried out by Oppelt (1987) it was discovered that the arsenic content of hazardous waste varied widely, as arsenic could be emitted from the incineration of any of these types of hazardous waste oils, halogenated and non-halogenated solvents, other organic liquids, and pesticides/herbicides. For chromium, the mean values in healthcare, quarry, road construction, asphalt, and brewery industries, were significantly different ($p<0.05$) from their controls. The peak values of chromium were from samples near the healthcare industry and road construction which exceeded FMEnv. Standard (1991) limit of 0.1 mg/kg. The report made by Wuana & Okieimen (2011), revealed that heavy metals and metalloids might contaminate soils through emissions from the proliferation of industrial areas. Heavy metals constitute an ill-defined group of inorganic chemical hazards, and those most commonly found at contaminated sites included, lead (Pb), chromium (Cr), arsenic (As), cadmium (Cd) and mercury (Hg). Heavy metals become contaminants in the soil due to certain factors: their rates of generation via human-made cycles were more relative to natural ones.

In the microbial analysis of soil, the mean values of total bacteria count, in healthcare, quarry, road construction, asphalt and brewery industries, were significantly different ($p<0.05$) from their controls. For total hydrocarbon utilizing bacterial (HUB), the mean values in healthcare, quarry, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls. The mean value of total HUB in the road construction industry was significantly different ($p<0.05$) from the control. For total fungi count, the mean values in quarry, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls while the mean values of total fungi count in healthcare and road construction industries, were significantly different ($p<0.05$) from their controls. For total hydrocarbon utilizing (HUF) fungi, the mean values in healthcare, quarry, road construction, asphalt and brewery industries, were significantly different ($p<0.05$) from their controls. The colony-forming unit counts in this research were recorded to be higher in contaminated soil than unpolluted soil, and microbial counting of a contaminated site was the simplest method for monitoring microbial activities that can be used for bioremediation. Similar reports were made by Chikere & Ekwuabu (2014); Ataikiru *et al.* (2017). ANOVA ($p<0.05$) analysis showed significant difference in the mean concentrations of the physicochemical properties of measured soil parameters.

4.2.6 Heavy metal analysis of leaf samples of *Manihot esculenta* and *Carica papaya* plants near selected industries, South-Eastern Nigeria.

In *Manihot esculenta,* the mean values of lead, in healthcare, quarry, road construction, asphalt, and brewery industries, were significantly different ($p<0.05$) from their controls. However, the concentrations of lead were within the limits of the Codex Standard (2010). For cadmium, the mean values in healthcare, quarry, road construction and brewery industries were not significantly different ($p>0.05$) from their controls while the mean value of asphalt industry was significantly different ($p<0.05$) from the controls. For mercury, the mean values in healthcare, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls while the mean value of mercury in quarry industry was significantly different ($p<0.05$) from the control. For arsenic, the mean value of arsenic in quarry industry, was not significantly different ($p>0.05$) from the control while the mean values of arsenic in healthcare, road construction, asphalt and brewery industries, were significantly different ($p<0.05$) from their controls. For chromium, the mean values in healthcare road construction and brewery industries, were not significantly different ($p>0.05$) from their controls, while the mean values in quarry and asphalt industries, were significantly different ($p<0.05$) from their controls.

Garden produce grown in soils with lead levels less than 300 ppm were considered as safe levels. Rosen, (2002) had similar report on lead levels of soils. Weinberg (2014) said that low doses of chemical contaminants had been proven to be carcinogenic. The comparative study carried out by Abua, & Eyo (2013) on the influence of heavy metals on soil and crops growing within the quarry environment at Akamkpa, Cross River State, Nigeria, concluded that quarry activities in old Netim in Akamkpa local government area of Cross River State had a significant impact on the level of heavy metals on crops around the area. The environmental and health implications were a matter of great concern since man and livestock depended on these plant species for food. Statistical analysis revealed a significant difference in the mean concentrations of the measured heavy metal pollutants: lead, cadmium, mercury, arsenic and chromium, relative to the control. Therefore, the findings in this research showed that various activities in industries resulted in the accumulation of trace metals in the soils and vegetation

In *Carica papaya* near industries covered the mean values of lead, in healthcare, quarry, road construction, asphalt and brewery industries were significantly different ($p<0.05$) from their controls. For cadmium, the mean values in healthcare, road construction, asphalt and brewery industries were not significantly different ($p>0.05$) from their controls, while the mean values in quarry industry was significantly different ($p<0.05$) from the controls. For mercury, the mean values, in healthcare, quarry, road construction, asphalt and brewery industries were significantly different ($p<0.05$) from their controls. For arsenic, the mean values of arsenic in healthcare, quarry, road construction, asphalt and brewery industries, were not significantly different ($p>0.05$) from their controls. For chromium, the mean values in healthcare, quarry, road construction, asphalt and brewery industries, were significantly different ($p<0.05$) from their controls.

There were variations in the levels of assessed heavy metals in *Carica papaya* near industries studied. Lead had the peak value of 0.44±0.01mg/kg in samples near the quarry, Ishiagu, which was above the Codex Standard (2010) limit. Cadmium was within the range of 0.01±0.00– 0.02±0.00mg/kg. Other heavy metals recorded lower values within the scope of 0.00±0.00 – 0.02±0.00mg/kg. Osuocha (2016) in a research: Seasonal impact on phytoaccumulation potentials of selected edible vegetables grown in Ishiagu quarry mining effluent discharge soils, showed a significant increase in the level of trace metals in roots and shoots in the dry season compared to the wet season. In the study, the concentration of these metals was significantly higher compared to control. This was indicative of the potential risk associated with consumption of vegetables grown in the sites, especially in dry seasons.

4.2.7 Proximate analysis of leaf samples of *Manihot esculenta* and *Carica papaya* in selected industries, South-Eastern Nigeria.

The mean values of the moisture content of *Manihot esculenta* and *Carica papaya* in healthcare, quarry, road construction, asphalt and brewery industries were significantly different ($p<0.05$) from their controls. Awoyinka, Abegunde & Adewusi (1995) in the research on young cassava leaves nutrient and assessment of their acceptance as a green vegetable in Nigeria recorded high moisture and fibre content of the leaves. *Manihot esculenta* collected near road construction industry recorded peak values of moisture and the fibre content of the leaves. The ash content, of *Manihot esculenta* and *Carica papaya* in all the industries studied, were significantly different ($p<0.05$) from their controls. The studies of Maisarah (2014) showed lower values of ash content. Quarry, Ishiagu had the peak values of ash content in *Manihot esculenta* and *Carica papaya*. Sánchez-Jiménez *et al.* (2012) reported that dust from quarrying settled mostly on leaves and retards the growth of the plant as it interferes with the photosynthetic processes. However, the results of the ash content in this research showed moderate values which suggested that the leaves of *Manihot esculenta* and *Carica papaya* would provide essential minerals. These values were similar to those reported by Puwastien (2000) and Maisarah (2014) on the research, proximate analysis, antioxidant and antiproliferative activities of different parts of *Carica papaya*.

The crude protein content of *Manihot esculenta* and *Carica papaya* mean values in all the industries studied, were significantly different ($p<0.05$) from their controls except *Manihot esculenta* in quarry industry. Wanapat (2001) reported higher crude protein content of 200 to 300 g/kg DM for dried cassava leaves. The variation in the crude protein content may at least partly be attributed to varietal leaf differences. Ravindran (1988) reported that *Manihot* *esculenta* Crantz leaves contained a high level of crude protein (29.3–32.4% dry weight) compared to a conventional vegetable, Amaranthus. The study of Oni (2011) on the nutritive value of leaves of four varieties of cassava also agreed with very high crude protein contents. The leaves compared favourably with other green vegetables generally regarded as good protein sources. Aletor & Adeogun (1995) made a similar report in the research on Nutrients and anti-nutrient components of some tropical leafy vegetables. Furthermore, research by Devend (1977), on Cassava as animal feed suggested, that the amino acid profile of cassava leaf protein compares favourably with those of milk, cheese, soybean, fish and egg.

The mean values of crude lipid content, in all the industries studied, were significantly different ($p<0.05$) from their controls. In the research carried out by Hun-Teik & Hui-Ling (1981) on the lipids of young cassava leaves (*Manihot esculenta*, Crantz) analysis of the fatty acid composition of each of the leaf lipid, revealed that, except for steryl esters, all leaf lipids had high content of polyunsaturated fatty acids. The crude fat content reported by Puwastien (2000), was similar to the results in this study, while that reported by Maisarah (2014) was lower than the findings in this research. The peak values of lipid content (3.81±0.01%) recorded in a sample of *Manihot esculenta* near the brewery, Awo-omamma, could be as a result of the high lipid content of hop used extensively in the brewery, a similar report by Annuss & Rhed (1985). Similarly, the high content of leaf fatty acids in *Carica papaya* samples near road construction industry could be from automobile engine oil. The report by JuÃ¡rez-Rojop (2012) on the use of aqueous extract of *Carica papaya* in diabetic rat concluded that, it prevented the accumulation and storage of lipids by the liver which showed its affinity to lipids and was used as an anti-diabetic agent in rat.

The crude fibre content of *Manihot esculenta* and *Carica papaya* in all the industries studied were significantly different ($p<0.05$) from their controls. These findings were similar to the report by Nwofia (2012) on the chemical composition of leaves, fruit pulp, and seeds in some *Carica papaya* (L) morphotypes. The crude fibre content enhanced water absorption, improved digestion, softened and increased bulk in stool, thereby preventing constipation. The crude carbohydrate content of *Manihot esculenta* and *Carica papaya* mean values in all the industries studied, were significantly different ($p<0.05$) from their controls except the crude carbohydrate content of *Manihot esculenta* in the road construction industry. The peak value of carbohydrate content of *Manihot esculenta* was recorded in the asphalt industry while the peak value of carbohydrate content of *Carica papaya* was recorded in the brewery industry. According to Mallick & El-Korchi (2008), a group of minerals composed of silicon and oxygen were found in asphalt, concrete and rocks. Quinn (2017) reported that the use of silicon as fertilizer was gaining ground and the primary food sources of silicon were unrefined grains, cereal products and root vegetables. More so, silicon promoted photosynthesis in plants enhanced growth, increased yields and improved quality. Asare *et al*. (2011) reported that in the brewery industry barley was commonly used as a source of malt for an alcoholic beverage, beer. More so, starch was the major component of the barley kernel and amounted to over 72.2% of the dry weight. Gil & Buitrago (2002) found that the carbohydrates in cassava leaves were mainly starch, with amylose content varying from 19% to 24%. The research carried out by Neji, Ushie, Neji, Ogah, & Vaal (2018) on phytochemical, proximate composition and vitamin C. content of *Carica papaya* reported values higher than the mean values recorded in this research. However, *Manihot esculenta* and *Carica papaya* were good sources of macronutrient, micronutrient, minerals and antioxidant compounds that can provide adequate nutrition leading to a better state of health in rural and urban populations. The high levels of nutrients in leaf samples of *Manihot esculenta* and *Carica papaya* were beneficial to man.

Chapter V: Conclusion and Recommendations

5.1 Conclusion

The results obtained in this research on some occupational and ecotoxicological hazards showed that the work environments were contaminated and had possible adverse health effects on workers. Occupational health indices recorded were: Pulmonary consolidation (a possible biomarker to lung cancer/pneumonitis) among males in the quarry, road construction and only females in the brewery industry. Status Asthmaticus (a potential biomarker of susceptibility) among asphalt industry workers. Lymphocytosis among males and eosinophilia with peak values of ESR among the female workers (were possible inflammatory biomarkers). Also recorded were, monocytosis among asphalt workers and basophilia among road construction males. Alopecia areata (with "i hair" as a potential biomarker), in the brewery industry. The brewery worker got undue exposure when chemicals were mixed and as chemical spills were cleaned up. The exposure possibly resulted in inflammatory infiltrates around the lower portion of the anagen hair follicle, that led to arrest and subsequent destruction of the hair follicle which appeared as black dots and referred to as "i hair".

The air quality in all the industries studied was polluted with sulphur (IV) oxide. Based on the spike above the NESREA (1991) standard limit for all the parameters of air quality assessment in the five industries studied, the asphalt industry had the worst air quality. Chest x-ray of the workers revealed that 5% of the asphalt industry male worker had TB. Pulmonary consolidation was seen mostly among road construction workers (29%) and the condition was marked with hardening of the normally aerated soft tissue of the lung, which may precede lung cancer. The affected workers were subjected to further investigations (Computerised Tomography-guided core biopsy of the mass and a Positron Emission Tomography scan) and management with follow up. The inability of Nigerian ministries and agencies; the Federal Ministry of Environment (FMEnv), National Environmental Standards and Regulations

Enforcement Agency (NESREA), and Nigerian Meteorological Agency (NIMET) to systematically and consistently measure the concentrations of air pollutants hinder concerted efforts to achieving clean air in Nigeria. However, the findings in this research would contribute to data on the concentration of air pollutants. The ecotoxicological hazards were often connected with small-scale industries, where occupational exposure to hazardous chemicals was not given appropriate consideration. Also, these small industrial plants often discharge hazardous wastes to surface and groundwater, soil and sometimes contaminating the food chain. The population increase, furthermore, magnifies the environmental impacts of chemicals and chemical pollution. A wave of industrialisation took place with a significant increase in the production and processing of metal and chemical products. The chemical contamination of air, water, and soil in this research was statistically significant, and low doses of chemical contaminants had been proven to be carcinogenic. Most industries were located in or close to large urban areas on coastlines, within the water catchment areas of major rivers or significant underground water resources. Njaba river near a brewery was contaminated with arsenic. Industrial toxicants had significant effects on the freshwater and soil around the workplace, and adjoining environments such as the predominance of lead and total bacterial count. Groundwater contamination was nearly always the result of human activity. It was contaminated by virtually any activity whereby chemicals or wastes may be released to the environment and was difficult and expensive to clean up. The contamination of groundwater and surface water invariably affected nearby river or stream as were recorded in Nworie river that had exudates from the healthcare and road construction, the Akpoha river near the quarry, Akpou-ga river near asphalt and Njaba river near brewery industries. More so, there was lead contamination of the leaves of *Manihot esculenta* and *Carica papaya* in soils around the work environment. There was no growth of total hydrocarbon utilizing bacteria and fungi in quarry and asphalt industries with sandy soil. The workplace was indeed contaminated and workers are exposed to the hazards that emanate from it.-

5.2 Recommendations

This study did not only seek to secure the safety and health of at work but consequentially created awareness among workers, employers, trade unions and the general public on the relationship between work, ecosystem, and health. It also assisted in early rehabilitation, maintenance well-being and functional work environment. The study also saw the need for the industries so far studied to identify with the National Occupational Safety and Health System. It was imperative to keep a comprehensive record, through the development of new longitudinal data sets for various jobs, as well as objective information on the occupational hazard in South-Eastern Nigeria. Further research was necessary to know the effects of asphalt fumes on immune cells. The industrial managers should as a matter of urgency collaborate with NESREA to check various levels of contamination due to prolonged industrial activities with the high level of air, water and soil pollution, climate change, chemical safety and healthcare waste. Evaluation research is needed to determine the degree to which public policies were intended to enable workers to remain healthy and productive. The large population around the world who were willing to contribute their data through smartphones to advance research should be encouraged by researchers. Digital biomarkers translated new data sources into informative, actionable insights. These were worker-generated physiological and behavioural measures collected through connected digital tools which expanded the population that can generate health data.

Contributions to Knowledge

The Research has the following contributions to knowledge:

i. Generation of baseline data in some occupational and ecotoxicological hazards in healthcare, quarry, road construction, asphalt, and brewery industries.

ii. Identification of sensitive indices per industry/generalized features described in the next page, which can serve for the development of industry standards and guidelines, routine medical checks and continuous improvement.

Industry / Generalized features	**Sensitive indices / Indicators**	**Indicative of:**	**Impact or implication**
Healthcare	cardiothoracic ratio and transverse cardiac diameter	exposure to embalming chemical	possible sign of cardiomegaly
	cadmium content of hair	exposure to cadmium present in the air	possible sign of "**itai-itai" disease**
Quarrying	opacities, hyper inflated lungs and dull percussion note	accidental inhalation of mercury	possible sign of **pneumonitis**
Road construction	consolidation of the lung	inhalation of mineral dust	possible biomarker to **lung cancer**
Asphalt	ARDS:- **status asthmaticus**	inhalation of asphalt fumes	a possible biomarker of susceptibility
	sputum +AFB, opacities upper lobe ®lung with pleural effusion, cavitations & hilar lymphadenopathy	infection of *mycobacterium tuberculosis*	diagnosis of **pulmonary tuberculosis**
Brewery	**autoimmune disease,** which made the hair to appear like the letter **'i'**	exposure to the chemical sanitation used in the brewing industry	potential prognostic marker to **alopaecia areata**
Generalized features			
Haematological	high ESR, lymphocytosis, monocytosis, eosinophilia	erythrocyte sedimentation rate and WBC differential count	are possible **inflammatory** biomarker
Air quality	high values of: NO_2, CO_2 CO, SO_2, TSPM10 & VOCs	presence of industrial pollutants	may count as unhealthy **air quality index**
Physicochemical / microbiological	predominance of lead and pathogenic bacteria	exposure to industrial toxicants	possible **environmental contaminants** of freshwater and soil
Heavy metal / macronutrients	significant presence of lead in plants	uptake of lead mainly through the root	possible **contaminants** of food chain and toxic element in plant

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Appendices

Appendix 1a (i)

Analysis of Variance. Cardiothoracic ratio of male workers in selected industries in South-Eastern Nigeria

ANOVA: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	11	4.46	0.40545455	8.7273E-05
Column 2	14	5.54	0.39571429	7.2527E-05
Column 3	11	5.15	0.46818182	0.00113636
Column 4	10	3.5	0.35	0.00277778
Column 5	8	2.8	0.35	3.5217E-33

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.09630411	4	0.02407603	30.8996715	7.42339E-13	2.56112403
Within Groups	0.03817922	49	0.00077917			
Total	0.13448333	53				

Appendix 1a (ii)

Analysis of Variance. Cardiothoracic ratio of female workers in selected industries in South-Eastern Nigeria

ANOVA: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	28	9.8	0.35	0.00185
Column 2	12	3.96	0.33	0.00098
Column 3	12	4.8	0.4	0.00545
Column 4	10	3.5	0.35	6.7E-05
Column 5	11	3.63	0.33	0

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.038931507	4	0.00973	5.45169	0.00072	2.506621016
Within Groups	0.1214	68	0.00179			
Total	0.160331507	72				

Appendix 1b (i)

Analysis of Variance: Transverse cardiac diameter of the male workers in selected industries in South-Eastern Nigeria

ANOVA: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	11	169.18	15.38	0.00016
Column 2	14	215.32	15.38	0.00012
Column 3	11	168.5	15.3182	0.00114
Column 4	10	143.5	14.35	0.00278
Column 5	8	122.24	15.28	0

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	8.16125	4	2.04031	2526.95	4.45433E-56	2.561124034
Within Groups	0.03956	49	0.00081			
Total	8.20081	53				

Appendix 1b (ii)

Analysis of Variance. Transverse cardiac diameter of the female workers in selected industries in South-Eastern Nigeria

ANOVA: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	28	400.4	14.3	0.00148
Column 2	12	171.1	14.2583	0.00265
Column 3	16	228	14.25	0.00133
Column 4	10	143.5	14.35	0.00222
Column 5	11	156.75	14.25	0.0025

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.08966	4	0.02242	12.0295	1.53527E-07	2.49892
Within Groups	0.13417	72	0.00186			
Total	0.22383	76				

Appendix 2a

Analysis of Variance. WBC Total count of male workers in selected industries in South Eastern Nigeria

ANOVA: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	14	80400	5742.857143	662637.36
Column 2	11	58000	5272.727273	224181.82
Column 3	15	73732	4915.466667	173423.7
Column 4	10	47500	4750	36111.111
Column 5	8	39880	4985	40201.143

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7717916.4	4	1929479.093	7.3620681	8.59492E-05	2.5462731
Within Groups	13890444	53	262083.8421			
Total	21608360	57				

Appendix 2b

Analysis of Variance. WBC Total count of female workers in selected industries in South-Eastern Nigeria

ANOVA: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	16	93200	5825	298000
Column 2	12	58800	4900	330909.09
Column 3	16	75100	4693.75	108625
Column 4	10	44675	4467.5	76673.611
Column 5	11	52500	4772.7273	80181.818

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	15906283	4	3976570.7	21.243773	5.95493E-11	2.5252151
Within Groups	11231256	60	187187.59			
Total	27137538	64				

Appendix 3

Analysis of variance: Air quality in selected industries in South-Eastern Nigeria

ANOVA: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	3	2.4	0.8	1.92
Column 2	4	4.6	1.15	0.19667
Column 3	4	4.2	1.05	0.19667
Column 4	4	18.9	4.725	0.02917
Column 5	4	3.2	0.8	1.28

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	45.1199	4	11.28	17.6496	2.32553E-05	3.11225
Within Groups	8.9475	14	0.63911			
Total	54.0674	18				

Appendix 4

Analysis of variance: Physicochemical properties of water

ANOVA: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	5	148.87	29.774	5.09733
Column 2	5	36.13	7.226	0.36883
Column 3	5	10293.44	2058.688	6697590
Column 4	5	2976.68	595.336	433401.1
Column 5	5	18.85	3.77	0.755
Column 6	5	12.27	2.454	1.26508
Column 7	5	233.34	46.668	3510.647
Column 8	5	52.74	10.548	178.2757
Column 9	5	39.65	7.93	23.62845
Column 10	5	12.97	2.594	2.34628
Column 11	5	4.02	0.804	0.75683
Column 12	5	0.52	0.104	0.00358
Column 13	5	0.52	0.104	0.00303
Column 14	5	0.479333	0.095867	0.006989
Column 15	5	0.54	0.108	0.00447

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	20429070	14	1459219	3.067858	0.001272	1.8602423
Within Groups	28538857	60	475647.6			
Total	48967927	74				

Appendix 5

Analysis of variance: Physicochemical properties of soil in selected industries

ANOVA: Single Factor

SUMMARY

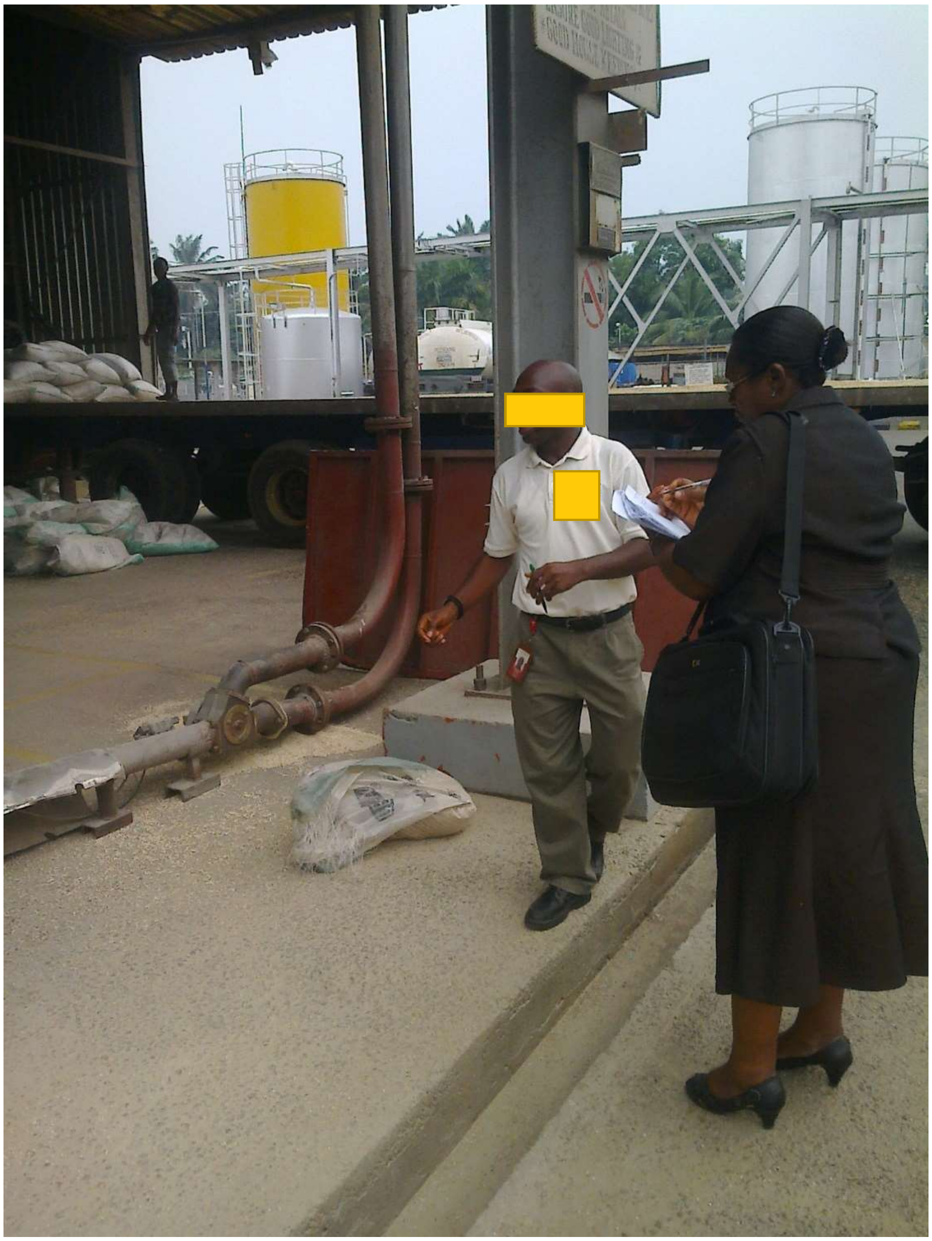
Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	5	29.29	5.858	4.95037
Column 2	5	4.739	0.9478	0.280279
Column 3	5	0.59	0.118	0.00047
Column 4	5	0.51	0.102	0.00037
Column 5	5	0.379	0.0758	0.013353
Column 6	5	0.45	0.09	0.00275

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	133.1640536	5	26.63281	30.45146	1.2044E-09	2.620654
Within Groups	20.9903696	24	0.874599			
Total	154.1544232	29				

Appendix 6

A researcher at brewery Awo-omamma during the fieldwork gathering anthropological data through the interviewing and observation of subjects in the field.



Appendix 7

A truck driver from Asphalt industry, Enugu that presented with hemoptysis and was diagnosed with tuberculosis.

Appendix 8

Asphalt industry at Enugu. Pail loader feeding the crushing machine

Appendix 9

Tanks for water supply in the asphalt industry Enugu.

Appendix 10

Dump site containing aggregates and asphalt at Enugu.

Appendix 11

Fine chipping used in asphalt industry Enugu to mix with sand and bitumen for road construction.

Appendix 12

Concrete tanks for asphalt effluence at Enugu

Appendix 13

Asphalt industry at Enugu.

Appendix 14

Unusual clouds sighted in Ishiagu quarry industry.

Appendix 15

Galleys (ravines) created at quarry site, Ishiagu from explosives. Ravines are an extreme form of erosion of the soil.

Appendix 16

Various sizes of crushed stone which generate dust particles in the quarry industry environment.

Appendix 17

The atmosphere above the quarrying site, Ishiagu gets cloudy, reducing visibility.

Appendix 18

Principles of the QBC II plus centrifugal haematology system procedure

The precision bore 75mm glass tube was utilised for venous blood which incorporates a black calibration line and customarily filled by semi-automated QBC pipette with 111.1µl. The test tube was internally coated with potassium oxalate and acridine orange. The fluorochrome stains the white cell. The potassium oxalate critically removes water from the erythrocytes, causing their density to increase and their volume to shrink. The effect of potassium oxalate tends to prevent commingling of erythrocytes of equal mass and leucocytes of the interfacing boundary between these cell layers. The QBC tube has plastic closure and float whose density approximates that of the white cells. The test tube is inserted into the sealed, filled tube before high-speed centrifugation is carried out. The float settles under centrifugal force into the buffy coat. The float expands the formed cell layers axially by a factor of 10. Some portion of the float also descends into the red cells (to a variable depth) similarly expanding the upper portion of the packed erythrocytes column and creating a visible lighter band of red cell surrounding the bottom part of the float. There are two red plasma level lines provided on the QBC venous-blood tube that is used to assess fill volume in the prepared blood tube before testing. Because of the displacement of the bulk of the specimen by the float, the plasma level should by principle after centrifugation of the blood tube, be between the two red lines. If the exact position of the plasma is not maintained, the blood tubes are discarded, and a new test tube prepared as the anomaly may be from a pipette malfunction. A "MODE" button is programmed into reading venous blood tube. The microscope aids in the control of the axial position of the test tube using an external knob on the side of the Reader. The test tube is "read" by sequentially aligning each interface starting from the zero position. A stationary reticle arrow in the optical system is utilised to "read". When the "ENTER" button is pressed, the length or thickness of each cell layer is fed into the Reader's micro-computer, each time an interface is aligned with the arrow. Values for the blood cells are displayed on the front panel of the Reader after the location of the last interface has been entered, and total of six interfaces in the venous blood.

Appendix 19

The principle of 'hot' Ziehl-Neelsen method of acid-fast staining

Mycobacteria Twere stained with the phenol-carbol fuchsin which was heated. The waxy mycobacterial cell wall can be penetrated by the hot dye and binds to the mycolic acid. An acid decolourising solution 3% v/v acid alcohol was applied which removed the red stain from the background cells, tissue fibres, and any organisms in the smear except mycobacteria which retained the dye hence referred to as *acid-fast bacilli* (AFB). After decolourisation, sputum smear was counterstained with methylene blue which provided a contrasting background against which the red AFB can be seen.

Appendix 20

Principles of Atomic Absorption Spectrophotometer.

Working principles: Atomic absorption spectrometry’s working principles are based on the sample being aspirated into flame and atomised when the AAS's light beam is directed through the flame into a monochromator, and onto the detector that measures the amount of light absorbed by the atomised element in the flame. Since metals have their characteristic absorption wavelength, a source lamp composed of that element is used, making the method relatively free from spectral or radiation interferences. The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample.

Appendix 21

Calculation of the Rate $\frac{\text{Incidence}}{\text{Sample size}} \times 1000$

Industrial population	Sample size	Consolidation	Rate per 1000	Males	Females
Healthcare 104,871	42	3	71 (7%)	24 (2%)	48 (5%)
Quarry 45,148	23	3	130 (13%)	87 (9%)	43 (4%)
Road construction 39,198	31	9	290 (29%)	161 (16%)	129 (13%)
Asphalt 19,088	20	2	100 (10%)	50 (5%)	50 (5%)
Brewery 7,998	19	2	105 (11%)	0	105 (11%)

Calculation of the projected population (2006 to 2018)

$$P_t = Po\ (1 + r)^t$$

Where: P_o = Initial population

P_t = Population (t) years later

r = growth rate 0.0299

Calculation of the RBC indices, which were routinely provided on hemogram results:

MCH (pg): This was equivalent to (Hgb ÷ RBC count) x g%

Conversion of haemoglobin g% to g/dl

$$\frac{14.1\ \text{g/dl} \times \text{g\%}}{100}$$

Appendix 22

Confidentiality Clause.

The following names were substituted for confidentiality based on the request of the institutions involved the actual names are withheld.

Healthcare industry, Owerri

Quarry Industry, Ishiagu

Road construction industry, Owerri

Asphalt industry, Enugu

Brewery, Awo-omamma

ONEWAY Haemoglobin (Hb),Total count (TC),Neutrophil (N), Lymphocyte (L), Monocytes (M,) Basophil (B),Eosinophil (E), ESR by HaematologicalParameters of Male Workers

/STATISTICS DESCRIPTIVES HOMOGENEITY
/MISSING ANALYSIS
/POSTHOC=DUNCAN ALPHA(0.05).

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound	Minimum	Maximum
Hb	Male Control	7	76.4286	6.65475	2.51526	70.2740	82.5832	69.00	84.00
	H workers	14	67.5643	2.97725	0.79570	65.8453	69.2833	62.00	72.50
	Q workers	11	71.4545	9.02622	2.72151	65.3906	77.5184	48.00	85.00
	R workers	15	71.0000	9.99285	2.58014	65.4661	76.5339	53.00	84.00
	A Workers	10	71.8000	13.75823	4.35073	61.9580	81.6420	48.00	90.00
	B Workers	8	78.0000	5.52914	1.95485	73.3775	82.6225	70.00	84.00
	Total	65	71.9062	9.03994	1.12127	69.6662	74.1461	48.00	90.00
TC	Male Control	7	5485.7143	595.61893	225.12279	4934.8587	6036.5699	4800.00	6200.00
	H workers	14	5742.8571	814.02541	217.55744	5272.8529	6212.8614	4200.00	6900.00
	Q workers	11	5272.7273	473.47842	142.75912	4954.6401	5590.8144	4600.00	6200.00
	R workers	15	4915.4667	416.44171	107.52479	4684.8489	5146.0844	4400.00	6100.00
	A Workers	10	4750.0000	190.02924	60.09252	4614.0613	4885.9387	4400.00	5000.00
	B Workers	8	4985.0000	200.50223	70.88824	4817.3759	5152.6241	4700.00	5300.00
	Total	65	5198.6462	617.24449	76.55976	5045.7005	5351.5919	4200.00	6900.00
N	Male Control	7	49.5714	1.71825	0.64944	47.9823	51.1605	48.00	52.00
	H workers	14	48.6429	2.67775	0.71566	47.0968	50.1889	42.00	52.00
	Q workers	11	48.0000	2.36643	0.71351	46.4102	49.5898	44.00	53.00
	R workers	15	49.4000	3.04256	0.78558	47.7151	51.0849	44.00	54.00
	A Workers	10	49.5000	3.02765	0.95743	47.3341	51.6659	43.00	53.00
	B Workers	8	49.1250	1.24642	0.44068	48.0830	50.1670	47.00	50.00
	Total	65	49.0000	2.53106	0.31394	48.3728	49.6272	42.00	54.00
L	Male Control	7	39.2857	6.39568	2.41734	33.3707	45.2007	30.00	44.00
	H workers	14	42.5000	2.76656	0.73939	40.9026	44.0974	34.00	45.00
	Q workers	11	42.5455	1.50756	0.45455	41.5327	43.5582	41.00	46.00
	R workers	15	42.8000	1.26491	0.32660	42.0995	43.5005	40.00	46.00
	A Workers	10	43.4000	1.50555	0.47610	42.3230	44.4770	42.00	47.00
	B Workers	8	42.3750	0.91613	0.32390	41.6091	43.1409	41.00	44.00
	Total	65	42.3538	2.78630	0.34560	41.6634	43.0443	30.00	47.00

M	Male Control	7	2.1429	1.57359	0.59476	0.6875	3.5982	0.00	4.00
	H workers	14	3.0714	0.82874	0.22149	2.5929	3.5499	2.00	5.00
	Q workers	11	2.6364	0.67420	0.20328	2.1834	3.0893	2.00	4.00
	R workers	15	2.8667	1.18723	0.30654	2.2092	3.5241	1.00	5.00
	A Workers	10	34.7000	16.99052	5.37287	22.5457	46.8543	2.00	44.00
	B Workers	8	3.5000	1.06904	0.37796	2.6063	4.3937	2.00	5.00
	Total	65	7.7692	13.24855	1.64328	4.4864	11.0521	0.00	44.00
B	Male Control	7	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	H workers	14	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Q workers	11	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	R workers	15	2.6667	3.97612	1.02663	0.4648	4.8686	0.00	10.00
	A Workers	10	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	B Workers	8	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	65	0.6154	2.17724	0.27005	0.0759	1.1549	0.00	10.00
E	Male Control	7	4.8571	2.19306	0.82890	2.8289	6.8854	3.00	9.00
	H workers	14	5.4286	2.70937	0.72411	3.8642	6.9929	0.00	9.00
	Q workers	11	6.8182	2.40076	0.72386	5.2053	8.4310	2.00	9.00
	R workers	15	4.9333	2.40436	0.62080	3.6018	6.2648	0.00	9.00
	A Workers	10	5.1000	2.68535	0.84918	3.1790	7.0210	2.00	10.00
	B Workers	8	5.0000	1.77281	0.62678	3.5179	6.4821	3.00	8.00
	Total	65	5.3846	2.43472	0.30199	4.7813	5.9879	0.00	10.00
ESR	Male Control	7	22.1429	1.86445	0.70470	20.4185	23.8672	20.00	26.00
	H workers	14	54.5000	8.29968	2.21818	49.7079	59.2921	45.00	73.00
	Q workers	11	71.4545	20.97314	6.32364	57.3646	85.5445	30.00	96.00
	R workers	15	53.6667	23.17532	5.98384	40.8326	66.5007	10.00	86.00
	A Workers	10	34.9000	16.84867	5.32802	22.8472	46.9528	10.00	60.00
	B Workers	8	36.0000	33.43223	11.82008	8.0500	63.9500	7.00	90.00
	Total	65	48.4000	24.32707	3.01740	42.3720	54.4280	7.00	96.00

Legend:

H. Healthcare

Q. Quarry

R. Road construction

A. Asphalt

B. Brewery

C. Control

HB Haemoglobin

TC White Blood Cell Total count

N Neutrophil

L Lymphocyte

M Monocyte

B Basophil

E Eosinophil

ESR Erythrocyte Sedimentation Rate

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
2.905	5	59	0.021
4.678	5	59	0.001
1.093	5	59	0.374
10.293	5	59	0.000
15.294	5	59	0.000
45.777	5	59	0.000
0.493	5	59	0.780
6.467	5	59	0.000

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HB	Between Groups	718.844	5	143.769	1.88	0.111
	Within Groups	4511.274	59	76.462		
	Total	5230.118	64			
TC	Between Groups	8364393.804	5	1672878.761	6.161	0
	Within Groups	16019015.06	59	271508.73		
	Total	24383408.86	64			
N	Between Groups	20.096	5	4.019	0.608	0.694
	Within Groups	389.904	59	6.609		
	Total	410	64			
L	Between Groups	80.531	5	16.106	2.282	0.058
	Within Groups	416.331	59	7.056		
	Total	496.862	64			
M	Between Groups	8579.374	5	1715.875	38.143	0
	Within Groups	2654.165	59	44.986		
	Total	11233.538	64			
B	Between Groups	82.491	5	16.498	3.787	0.005
	Within Groups	257.048	59	4.357		
	Total	339.538	64			
E	Between Groups	29.629	5	5.926	1	0.426
	Within Groups	349.755	59	5.928		
	Total	379.385	64			
ESR	Between Groups	14662.282	5	2932.456	7.453	0
	Within Groups	23213.318	59	393.446		
	Total	37875.6	64			

Post Hoc Tests

Homogeneous Subsets

Hb

Duncan[a,b]

Haematological Parameters of Male Workers	N	Subset for alpha = 0.05	
		1	2
H. workers	14	67.5643	
R. workers	15	71.0000	71.0000
Q. workers	11	71.4545	71.4545
A. Workers	10	71.8000	71.8000
Male Control	7		76.4286
B. Workers	8		78.0000
Sig.		0.330	0.115

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 10.053.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

TC

Duncan[a,b]

Haematological Parameters of Male Workers	N	Subset for alpha = 0.05		
		1	2	3
A. workers	10	4750.0000		
R. workers	15	4915.4667	4915.4667	
B. workers	8	4985.0000	4985.0000	
Q. workers	11		5272.7273	5272.7273
Male Control	7			5485.7143
H workers	14			5742.8571
Sig.		0.346	0.152	0.060

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 10.053.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

N

Duncan[a,b]

Haematological Parameters of Male Workers	N	Subset for alpha = 0.05
		1
Q. workers	11	48.0000
H. workers	14	48.6429
B. Workers	8	49.1250
R. workers	15	49.4000
A. Workers	10	49.5000
Male Control	7	49.5714
Sig.		0.239

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 10.053.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

L

Duncan[a,b]

Haematological Parameters of Male Workers	N	Subset for alpha = 0.05	
		1	2
Male Control	7	39.2857	
B. Workers	8		42.3750
H. workers	14		42.5000
Q. workers	11		42.5455
R. workers	15		42.8000
A. Workers	10		43.4000
Sig.		1.000	0.450

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 10.053.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

M

Duncan[a,b]

Haematological Parameters of Male Workers	N	Subset for alpha = 0.05	
		1	2
Male Control	7	2.1429	
Q. workers	11	2.6364	
R. workers	15	2.8667	
H. workers	14	3.0714	
B. Workers	8	3.5000	
A. Workers	10		34.7000
Sig.		0.692	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 10.053.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

B

Haematological Parameters of Male Workers	N	Subset for alpha = 0.05	
		1	2
H. workers	14	0.0000	
Q. workers	11	0.0000	
A. Workers	10	0.0000	
B. Workers	8	0.0000	
Male Control	7	0.0000	
R workers	15		2.6667
Sig.		0.179	0.189

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 10.053.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

E

Duncan[a,b]

Haematological Parameters of Male Workers	N	Subset for alpha = 0.05 1
Male Control	7	4.8571
R. workers	15	4.9333
B. Workers	8	5.0000
A. Workers	10	5.1000
H. workers	14	5.4286
Q. workers	11	6.8182
Sig.		0.119

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 10.053.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

ESR

Duncan[a,b]

Haematological Parameters of Male Workers	N	Subset for alpha = 0.05		
		1	2	3
Male Control	7	22.1429		
A. Workers	10	34.9000		
B. Workers	8	36.0000	36.0000	
R. workers	15		53.6667	53.6667
H. workers	14		54.5000	54.5000
Q. workers	11			71.4545
Sig.		0.145	0.052	0.061

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 10.053.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Haematological female Health Workers.

ONEWAY Hb, TC, N, L, M, B, E, ESR by Haematological Parameters Of Female Workers

STATISTICS DESCRIPTIVES HOMOGENEITY

/MISSING ANALYSIS

/POSTHOC=DUNCAN ALPHA(0.05).

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Hb	Female Control	8	69.2500	7.72288	2.73045	62.7935	75.7065	52.00	77.00
	H. workers	16	64.0625	2.46221	0.61555	62.7505	65.3745	60.00	71.00
	Q. workers	12	66.0000	12.74220	3.67836	57.9040	74.0960	37.00	77.00
	R. workers	16	66.1875	10.08113	2.52028	60.8156	71.5594	46.00	79.00
	A. Workers	10	55.9000	12.99957	4.11083	46.6007	65.1993	42.00	75.00
	B. Workers	11	64.4545	9.53272	2.87422	58.0504	70.8587	40.00	75.00
	Total	73	64.3562	10.02964	1.17388	62.0161	66.6963	37.00	79.00
TC	Female Control	8	4887.5000	343.08475	121.29878	4600.6740	5174.3260	4300.00	5300.00
	H. workers	16	5825.0000	545.89376	136.47344	5534.1137	6115.8863	4300.00	6500.00
	Q. workers	12	4900.0000	575.24698	166.05950	4534.5055	5265.4945	4000.00	6200.00
	R. workers	16	4693.7500	329.58307	82.39577	4518.1276	4869.3724	4100.00	5200.00
	A. Workers	10	4467.5000	276.90000	87.56347	4269.4177	4665.5823	4100.00	4800.00
	B. Workers	11	4772.7273	283.16394	85.37714	4582.4951	4962.9594	4300.00	5200.00
	Total	73	4977.7397	623.99533	73.03313	4832.1508	5123.3286	4000.00	6500.00

N	Female Control	8	46.3750	3.81491	1.34878	43.1857	49.5643	42.00	51.00
	H. workers	16	48.2500	3.92428	0.98107	46.1589	50.3411	44.00	59.00
	Q. workers	12	48.3333	2.93361	0.84686	46.4694	50.1973	42.00	52.00
	R. workers	16	46.6563	3.16606	0.79152	44.9692	48.3433	40.00	50.00
	A. Workers	10	48.0000	2.62467	0.82999	46.1224	49.8776	44.00	53.00
	B. Workers	11	48.3636	2.33550	0.70418	46.7946	49.9326	44.00	51.00
	Total	73	47.6918	3.20874	0.37556	46.9431	48.4404	40.00	59.00
L	Female Control	8	42.1250	0.83452	0.29505	41.4273	42.8227	41.00	43.00
	H. workers	16	42.8750	1.40831	0.35208	42.1246	43.6254	39.00	45.00
	Q. workers	12	42.5833	1.67649	0.48396	41.5181	43.6485	40.00	47.00
	R. workers	16	43.3125	2.05649	0.51412	42.2167	44.4083	40.00	50.00
	A. Workers	10	42.8750	1.61267	0.50997	41.7214	44.0286	41.75	47.00
	B. Workers	11	43.0000	0.89443	0.26968	42.3991	43.6009	42.00	44.00
	Total	73	42.8596	1.53262	0.17938	42.5020	43.2172	39.00	50.00
M	Female Control	8	3.1250	0.99103	0.35038	2.2965	3.9535	1.00	4.00
	H. workers	16	2.8750	0.61914	0.15478	2.5451	3.2049	2.00	4.00
	Q. workers	12	2.5833	0.99620	0.28758	1.9504	3.2163	1.00	4.00
	R. workers	16	2.6250	0.61914	0.15478	2.2951	2.9549	2.00	4.00
	A. Workers	10	42.0000	1.94365	0.61464	40.6096	43.3904	40.00	47.00
	B. Workers	11	3.1818	0.60302	0.18182	2.7767	3.5869	2.00	4.00
	Total	73	8.2055	13.59326	1.59097	5.0339	11.3770	1.00	47.00
B	Female Control	8	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	H. workers	16	0.2500	0.77460	0.19365	-0.1628	0.6628	0.00	3.00
	Q. workers	12	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	R. workers	16	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	A. Workers	10	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	B. Workers	11	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	73	0.0548	0.36857	0.04314	-0.0312	0.1408	0.00	3.00

E	Female Control	8	4.6250	1.59799	0.56497	3.2890	5.9610	3.00	7.00
	H. workers	16	6.0000	3.14113	0.78528	4.3262	7.6738	0.00	10.00
	Q. workers	12	5.9167	2.50303	0.72256	4.3263	7.5070	3.00	10.00
	R. workers	16	5.9375	2.11246	0.52812	4.8118	7.0632	3.00	10.00
	A. Workers	10	7.2900	2.58132	0.81629	5.4434	9.1366	3.50	10.00
	B. Workers	11	6.0000	2.23607	0.67420	4.4978	7.5022	4.00	10.00
	Total	73	5.9986	2.48219	0.29052	5.4195	6.5778	0.00	10.00
ESR	Female Control	8	24.1250	1.80772	0.63913	22.6137	25.6363	22.00	27.00
	H. workers	16	62.6250	30.19023	7.54756	46.5378	78.7122	12.00	100.00
	Q. workers	12	55.7500	30.61825	8.83873	36.2961	75.2039	13.00	100.00
	R. workers	16	70.6875	28.65128	7.16282	55.4203	85.9547	30.00	148.00
	A. Workers	10	39.7000	39.64860	12.53799	11.3371	68.0629	15.00	150.00
	B. Workers	11	46.8182	27.44747	8.27572	28.3787	65.2576	13.00	120.00
	Total	73	53.5205	31.93314	3.73749	46.0700	60.9711	12.00	150.00

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Hb	6.242	5	67	0.000
TC	1.089	5	67	0.374
N	1.176	5	67	0.330
L	0.342	5	67	0.886
M	2.129	5	67	0.073
B	5.397	5	67	0.000
E	1.827	5	67	0.119
ESR	1.881	5	67	0.109

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Hb	Between Groups	994.237	5	198.847	2.132	0.072
	Within Groups	6248.502	67	93.261		
	Total	7242.74	72			
TC	Between Groups	15979446.37	5	3195889.275	17.762	0
	Within Groups	12055205.68	67	179928.443		
	Total	28034652.06	72			
N	Between Groups	46.869	5	9.374	0.904	0.484
	Within Groups	694.446	67	10.365		
	Total	741.315	72			
L	Between Groups	8.738	5	1.748	0.73	0.603
	Within Groups	160.385	67	2.394		
	Total	169.123	72			
M	Between Groups	13236.99	5	2647.398	2650.245	0
	Within Groups	66.928	67	0.999		
	Total	13303.918	72			
B	Between Groups	0.781	5	0.156	1.163	0.337
	Within Groups	9	67	0.134		
	Total	9.781	72			
E	Between Groups	31.912	5	6.382	1.039	0.402
	Within Groups	411.698	67	6.145		
	Total	443.61	72			
ESR	Between Groups	15418.17	5	3083.634	3.562	0.006
	Within Groups	58002.049	67	865.702		
	Total	73420.219	72			

Post Hoc Tests

Homogeneous Subsets

Hb

Duncan[a,b]

Haematological Parameters of Female Workers	N	Subset for alpha = 0.05	
		1	2
A. Workers	10	55.9000	
H. workers	16		64.0625
B. Workers	11		64.4545
Q. workers	12		66.0000
R. workers	16		66.1875
Female Control	8		69.2500
Sig.		1.000	0.261

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 11.445.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

TC

Duncan[a,b]

Haematological Parameters of Female Workers	N	Subset for alpha = 0.05		
		1	2	3
A. Workers	10	4467.5000		
R. workers	16	4693.7500	4693.7500	
B. Workers	11	4772.7273	4772.7273	
Female Control	8		4887.5000	
Q. workers	12		4900.0000	
H. workers	16			5825.0000
Sig.		0.108	0.297	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 11.445.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

N

Duncan[a,b]

Haematological Parameters of Female Workers	N	Subset for alpha = 0.05
		1
Female Control	8	46.3750
R. workers	16	46.6563
A. Workers	10	48.0000
H. workers	16	48.2500
Q. workers	12	48.3333
B. Workers	11	48.3636
Sig.		0.204

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 11.445.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

L

Duncan[a,b]

Haematological Parameters of Female Workers	N	Subset for alpha = 0.05
		1
Female Control	8	42.1250
Q. workers	12	42.5833
H. workers	16	42.8750
A. Workers	10	42.8750
B. Workers	11	43.0000
R. workers	16	43.3125
Sig.		0.113

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 11.445.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

M

Duncan[a,b]

Haematological Parameters of Female Workers	N	Subset for alpha = 0.05	
		1	2
Q. workers	12	2.5833	
R. workers	16	2.6250	
H. workers	16	2.8750	
Female Control	8	3.1250	
B. Workers	11	3.1818	
A. Workers	10		42.0000
Sig.		0.209	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 11.445.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

B

Duncan[a,b]

Haematological Parameters of Female Workers	N	Subset for alpha = 0.05
		1
Female Control	8	0.0000
Q. workers	12	0.0000
R. workers	16	0.0000
A. Workers	10	0.0000
B. Workers	11	0.0000
H. workers	16	0.2500
Sig.		0.160

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 11.445.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

E

Duncan[a,b]

Haematological Parameters of Female Workers	N	Subset for alpha = 0.05	
		1	2
Female Control	8	4.6250	
Q. workers	12	5.9167	5.9167
R. workers	16	5.9375	5.9375
H. workers	16	6.0000	6.0000
B. Workers	11	6.0000	6.0000
A. Workers	10		7.2900
Sig.		0.245	0.246

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 11.445.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

ESR

Duncan[a,b]

Haematological Parameters of Female Workers	N	Subset for alpha = 0.05: 1	2	3
Female Control	8	24.1250		
A. Workers	10	39.7000	39.7000	
B. Workers	11	46.8182	46.8182	46.8182
Q. workers	12		55.7500	55.7500
H. workers	16		62.6250	62.6250
R. workers	16			70.6875
Sig.		0.085	0.093	0.080

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 11.445.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

HAIR

ONEWAY Lead, Cadmium, Mercury, Arsenic, Chromium by Heavy Metal Content Of Workers' Hair

STATISTICS DESCRIPTIVES HOMOGENEITY

/MISSING ANALYSIS

/POSTHOC=DUNCAN ALPHA(0.05).

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Lower Bound	95% Confidence Upper Bound	Minimum	Maximum
Lead (mg/l)	H hair	5	0.0100	0.00707	0.00316	0.0012	0.0188	0.00	0.02
	Q Hair	3	0.2600	0.03606	0.02082	0.1704	0.3496	0.22	0.29
	R Hair	3	0.2100	0.10000	0.05774	-0.0384	0.4584	0.11	0.31
	A Hair	3	0.0700	0.07211	0.04163	-0.1091	0.2491	0.01	0.15
	B Hair	3	0.0500	0.02000	0.01155	0.0003	0.0997	0.03	0.07
	H Control	5	0.0100	0.00707	0.00316	0.0012	0.0188	0.00	0.02
	Q Control	3	0.1700	0.01000	0.00577	0.1452	0.1948	0.16	0.18
	R Control	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	A Control	3	0.1000	0.10000	0.05774	-0.1484	0.3484	0.00	0.20
	B Control	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	Total	34	0.0806	0.09686	0.01661	0.0468	0.1144	0.00	0.31
Cadmium (mg/l)	H hair	5	0.6360	0.34486	0.15423	0.2078	1.0642	0.02	0.82
	Q Hair	3	0.1200	0.01000	0.00577	0.0952	0.1448	0.11	0.13
	R Hair	3	0.0900	0.01000	0.00577	0.0652	0.1148	0.08	0.10
	A Hair	3	0.2600	0.06083	0.03512	0.1089	0.4111	0.22	0.33
	B Hair	3	0.0500	0.02000	0.01155	0.0003	0.0997	0.03	0.07
	H Control	5	0.0520	0.02280	0.01020	0.0237	0.0803	0.02	0.08
	Q Control	3	0.0500	0.01000	0.00577	0.0252	0.0748	0.04	0.06
	R Control	3	0.0500	0.03000	0.01732	-0.0245	0.1245	0.02	0.08
	A Control	3	0.0200	0.01000	0.00577	-0.0048	0.0448	0.01	0.03
	B Control	3	0.0500	0.02000	0.01155	0.0003	0.0997	0.03	0.07
	Total	34	0.1621	0.24208	0.04152	0.0776	0.2465	0.01	0.82

Mercury (mg/l)	H hair	5	0.0180	0.00837	0.00374	0.0076	0.0284	0.01	0.03
	Q Hair	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	R Hair	3	0.1067	0.03512	0.02028	0.0194	0.1939	0.07	0.14
	A Hair	3	0.0800	0.04583	0.02646	-0.0338	0.1938	0.04	0.13
	B Hair	3	0.2000	0.10000	0.05774	-0.0484	0.4484	0.10	0.30
	H Control	5	0.0100	0.00707	0.00316	0.0012	0.0188	0.00	0.02
	Q Control	3	0.1000	0.10000	0.05774	-0.1484	0.3484	0.00	0.20
	R Control	3	0.0800	0.02000	0.01155	0.0303	0.1297	0.06	0.10
	A Control	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	B Control	3	0.1000	0.10000	0.05774	-0.1484	0.3484	0.00	0.20
	Total	34	0.0647	0.07411	0.01271	0.0388	0.0906	0.00	0.30
Arsenic (mg/l)	H hair	5	0.0960	0.07127	0.03187	0.0075	0.1845	0.00	0.20
	Q Hair	3	0.0200	0.01732	0.01000	-0.0230	0.0630	0.01	0.04
	R Hair	3	0.0200	0.01000	0.00577	-0.0048	0.0448	0.01	0.03
	A Hair	3	0.0200	0.01000	0.00577	-0.0048	0.0448	0.01	0.03
	B Hair	3	0.2000	0.00000	0.00000	0.2000	0.2000	0.20	0.20
	H Control	5	0.0580	0.02775	0.01241	0.0235	0.0925	0.01	0.08
	Q Control	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	R Control	3	0.0200	0.01000	0.00577	-0.0048	0.0448	0.01	0.03
	A Control	3	0.0900	0.01000	0.00577	0.0652	0.1148	0.08	0.10
	B Control	3	0.0200	0.01000	0.00577	-0.0048	0.0448	0.01	0.03
	Total	34	0.0579	0.06144	0.01054	0.0365	0.0794	0.00	0.20
Chromiuim (mg/l)	H hair	5	0.0200	0.01414	0.00632	0.0024	0.0376	0.00	0.04
	Q Hair	3	0.1100	0.07000	0.04041	-0.0639	0.2839	0.06	0.19
	R Hair	3	0.1200	0.01000	0.00577	0.0952	0.1448	0.11	0.13
	A Hair	3	0.1100	0.03464	0.02000	0.0239	0.1961	0.09	0.15
	B Hair	3	0.1000	0.10000	0.05774	-0.1484	0.3484	0.00	0.20
	H Control	5	0.0080	0.00447	0.00200	0.0024	0.0136	0.00	0.01
	Q Control	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	R Control	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	A Control	3	0.0100	0.00000	0.00000	0.0100	0.0100	0.01	0.01
	B Control	3	0.0100	0.00000	0.00000	0.0100	0.0100	0.01	0.01
	Total	34	0.0465	0.05762	0.00988	0.0264	0.0666	0.00	0.20

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Lead (mg/l)	3.344	9	24	0.009
Cadmium (mg/l)	3.528	9	24	0.006
Mercury (mg/l)	2.663	9	24	0.027
Arsenic (mg/l)	1.431	9	24	0.230
Chromiuim (mg/l)	4.693	9	24	0.001

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Lead (mg/l)	Between Groups	0.255	9	0.028	12.398	0.000
	Within Groups	0.055	24	0.002		
	Total	0.310	33			
Cadmium (mg/l)	Between Groups	1.445	9	0.161	7.871	0.000
	Within Groups	0.489	24	0.020		
	Total	1.934	33			
Mercury (mg/l)	Between Groups	0.113	9	0.013	4.405	0.002
	Within Groups	0.068	24	0.003		
	Total	0.181	33			
Arsenic (mg/l)	Between Groups	0.099	9	0.011	10.514	0.000
	Within Groups	0.025	24	0.001		
	Total	0.125	33			
Chromiuim (mg/l)	Between Groups	0.076	9	0.008	6.009	0.000
	Within Groups	0.034	24	0.001		
	Total	0.110	33			

Post Hoc Tests

Homogeneous Subsets

Lead (mg/l)

Heavy Metal Content Of Workers' Hair	N	Subset for alpha = 0.05				
		1	2	3	4	5
H. hair	5	0.0100				
H. Control	5	0.0100				
R. Control	3	0.0100				
B. Control	3	0.0100				
B. Hair	3	0.0500	0.0500			
A. Hair	3	0.0700	0.0700			
A. Control	3		0.1000	0.1000		
Q. Control	3			0.1700	0.1700	
R. Hair	3				0.2100	0.2100
Q. Hair	3					0.2600
Sig.		0.169	0.219	0.074	0.296	0.194

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.261.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Cadmium (mg/l)

Duncan[a,b]

Heavy Metal Content Of Workers' Hair	N	Subset for alpha = 0.05	
		1	2
A. Control	3	0.0200	
Q. Control	3	0.0500	
R. Control	3	0.0500	
B. Hair	3	0.0500	
B. Control	3	0.0500	
H. Control	5	0.0520	
R. Hair	3	0.0900	
Q. Hair	3	0.1200	
A. Hair	3	0.2600	
H. hair	5		0.6360
Sig.		0.076	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.261.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Mercury (mg/l)

Duncan[a,b]

Heavy Metal Content Of Workers' Hair	N	Subset for alpha = 0.05	
		1	2
Q. Hair	3	0.0100	
H. Control	5	0.0100	
A. Control	3	0.0100	
H. hair	5	0.0180	
A. Hair	3	0.0800	
R. Control	3	0.0800	
Q. Control	3	0.1000	
B. Control	3	0.1000	
R. Hair	3	0.1067	
B. Hair	3		0.2000
Sig.		0.057	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.261.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Arsenic (mg/l)

Duncan[a,b]

Heavy Metal Content Of Workers' Hair	N	Subset for alpha = 0.05		
		1	2	3
Q. Control	3	0.0100		
Q. Hair	3	0.0200		
R. Hair	3	0.0200		
A. Hair	3	0.0200		
R. Control	3	0.0200		
B. Control	3	0.0200		
H. Control	5	0.0580	0.0580	
A. Control	3		0.0900	
H. hair	5		0.0960	
B. Hair	3			0.2000
Sig.		0.110	0.169	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.261.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Chromiuim (mg/l)

Duncan[a,b]

Heavy Metal Content Of Workers' Hair	N	Subset for alpha = 0.05 1	2
H. Control	5	0.0080	
Q. Control	3	0.0100	
R. Control	3	0.0100	
A. Control	3	0.0100	
B. Control	3	0.0100	
H. hair	5	0.0200	
B. Hair	3		0.1000
A. Hair	3		0.1100
Q. Hair	3		0.1100
R. Hair	3		0.1200
Sig.		0.722	0.541

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.261.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

ONEWAY NO_2 , CO_2, CO, SO_2, VOC PM by AirQualityControl of Workers in Industries
STATISTICS DESCRIPTIVES HOMOGENEITY
/MISSING ANALYSIS
/POSTHOC=DUNCAN ALPHA(0.05).

Oneway

Descriptives

						95% Confidence			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
NO_2, ppm	H. AQC	3	0.0767	0.01528	0.00882	0.0387	0.1146	0.06	0.09
	Q. AQC	4	0.6500	0.36968	0.18484	0.0617	1.2383	0.20	1.10
	R. AQC	4	0.9250	0.25000	0.12500	0.5272	1.3228	0.60	1.20
	A. AQC	4	1.3250	0.34034	0.17017	0.7834	1.8666	1.00	1.80
	B. AQC	4	0.0800	0.01414	0.00707	0.0575	0.1025	0.06	0.09
	Control H. AQC	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Control Q. AQC	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Control R. AQC	3	0.0600	0.01000	0.00577	0.0352	0.0848	0.05	0.07
	Control A. AQC	3	0.4500	0.01000	0.00577	0.4252	0.4748	0.44	0.46
	Control B. AQC	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	34	0.4024	0.49966	0.08569	0.2280	0.5767	0.00	1.80
CO_2 (%)	H. AQC	3	13.2667	1.37961	0.79652	9.8395	16.6938	11.70	14.30
	Q. AQC	4	13.8250	1.86257	0.93128	10.8612	16.7888	11.80	16.30
	R. AQC	4	14.1250	3.09664	1.54832	9.1976	19.0524	11.20	16.90
	A. AQC	4	17.8250	1.68597	0.84299	15.1422	20.5078	15.60	19.70
	B. AQC	4	29.2675	11.75538	5.87769	10.5621	47.9729	13.27	40.80
	Control H. AQC	3	4.0000	1.00000	0.57735	1.5159	6.4841	3.00	5.00
	Control Q. AQC	3	12.2000	0.10000	0.05774	11.9516	12.4484	12.10	12.30
	Control R. AQC	3	11.2000	0.10000	0.05774	10.9516	11.4484	11.10	11.30
	Control A. AQC	3	15.2000	0.10000	0.05774	14.9516	15.4484	15.10	15.30
	Control B. AQC	3	11.2000	0.10000	0.05774	10.9516	11.4484	11.10	11.30
	Total	34	14.7462	7.39167	1.26766	12.1671	17.3253	3.00	40.80

CO, ppm	H. AQC	3	4.0000	3.60555	2.08167	-4.9567	12.9567	0.00	7.00
	Q. AQC	4	17.0000	3.52136	1.76068	11.3967	22.6033	12.20	20.40
	R. AQC	4	9.1750	6.35367	3.17684	-0.9351	19.2851	5.70	18.70
	A. AQC	4	42.9000	3.36749	1.68375	37.5416	48.2584	38.50	46.00
	B. AQC	4	4.0000	2.94392	1.47196	-0.6844	8.6844	0.00	7.00
	Control H. AQC	3	11.2000	0.20000	0.11547	10.7032	11.6968	11.00	11.40
	Control Q. AQC	3	6.0000	2.00000	1.15470	1.0317	10.9683	4.00	8.00
	Control R. AQC	3	4.0000	1.00000	0.57735	1.5159	6.4841	3.00	5.00
	Control A. AQC	3	4.0000	1.00000	0.57735	1.5159	6.4841	3.00	5.00
	Control B. AQC	3	4.0000	1.00000	0.57735	1.5159	6.4841	3.00	5.00
	Total	34	11.5265	12.71585	2.18075	7.0897	15.9632	0.00	46.00
SO2,ppm	H. AQC	3	0.8000	1.38564	0.80000	-2.6421	4.2421	0.00	2.40
	Q. AQC	4	1.1500	0.44347	0.22174	0.4443	1.8557	0.60	1.60
	R. AQC	4	1.0500	0.44347	0.22174	0.3443	1.7557	0.60	1.60
	A. AQC	4	4.7250	0.17078	0.08539	4.4532	4.9968	4.50	4.90
	B. AQC	4	0.8000	1.13137	0.56569	-1.0003	2.6003	0.00	2.40
	Control H. AQC	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Control Q. AQC	3	0.3000	0.20000	0.11547	-0.1968	0.7968	0.10	0.50
	Control R. AQC	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Control A. AQC	3	0.4000	0.10000	0.05774	0.1516	0.6484	0.30	0.50
	Control B. AQC	3	0.0100	0.00000	0.00000	0.0100	0.0100	0.01	0.01
	Total	34	1.0421	1.52117	0.26088	0.5113	1.5728	0.00	4.90

VOC, ppm	H. AQC	3	0.5333	0.41633	0.24037	-0.5009	1.5676	0.20	1.00
	Q. AQC	4	0.2000	0.28284	0.14142	-0.2501	0.6501	0.00	0.60
	R. AQC	4	0.2000	0.40000	0.20000	-0.4365	0.8365	0.00	0.80
	A. AQC	4	6.4250	2.17313	1.08657	2.9671	9.8829	4.00	8.80
	B. AQC	4	0.4725	0.38879	0.19440	-0.1462	1.0912	0.16	1.00
	Control H. AQC	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Control Q. AQC	3	0.2000	0.10000	0.05774	-0.0484	0.4484	0.10	0.30
	Control R. AQC	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Control A. AQC	3	3.0000	1.00000	0.57735	0.5159	5.4841	2.00	4.00
	Control B. AQC	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	34	1.1879	2.22952	0.38236	0.4100	1.9659	0.00	8.80
PM10μg/m3	H. AQC	3	5.5667	3.95769	2.28498	-4.2648	15.3981	1.00	8.00
	Q. AQC	4	59.7000	26.01730	13.00865	18.3007	101.0993	35.60	84.30
	R. AQC	4	62.0000	37.31916	18.65958	2.6169	121.3831	14.20	95.20
	A. AQC	4	92.3500	3.48569	1.74284	86.8035	97.8965	88.90	96.30
	B. AQC	4	5.1925	3.08527	1.54264	0.2831	10.1019	1.57	8.70
	Control H. AQC	3	5.6000	0.10000	0.05774	5.3516	5.8484	5.50	5.70
	Control Q. AQC	3	40.6000	0.10000	0.05774	40.3516	40.8484	40.50	40.70
	Control R. AQC	3	30.6000	0.10000	0.05774	30.3516	30.8484	30.50	30.70
	Control A. AQC	3	40.6000	0.10000	0.05774	40.3516	40.8484	40.50	40.70
	Control B. AQC	3	4.3000	0.03000	0.01732	4.2255	4.3745	4.27	4.33
	Total	34	37.0226	33.25673	5.70348	25.4188	48.6265	1.00	96.30

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
NO_2, ppm	2.876	9	24	0.019
CO_2 (%)	3.852	9	24	0.004
CO, ppm	2.397	9	24	0.042
SO2,ppm	5.377	9	24	0.000
VOC, ppm	10.047	9	24	0.000
PM10µg/m3	14.378	9	24	0.000

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
NO_2, ppm	Between Groups	7.292	9	0.810	20.546	0.000
	Within Groups	0.946	24	0.039		
	Total	8.239	33			
CO_2 (%)	Between Groups	1334.857	9	148.317	7.603	0.000
	Within Groups	468.156	24	19.506		
	Total	1803.012	33			
CO, ppm	Between Groups	5077.459	9	564.162	52.397	0.000
	Within Groups	258.408	24	10.767		
	Total	5335.866	33			
SO_2,ppm	Between Groups	67.313	9	7.479	19.840	0.000
	Within Groups	9.048	24	0.377		
	Total	76.360	33			
VOC, ppm	Between Groups	146.328	9	16.259	22.036	0.000
	Within Groups	17.708	24	0.738		
	Total	164.036	33			
PM10µg/m3	Between Groups	30193.054	9	3354.784	12.769	0.000
	Within Groups	6305.275	24	262.720		
	Total	36498.329	33			

Post Hoc Tests

Homogeneous Subsets

NO_2, ppm

Duncan[a,b]

AirQuality Control of Workers' Industries	N	Subset for alpha = 0.05			
		1	2	3	4
Control H. AQC	3	0.0000			
Control Q. AQC	3	0.0000			
Control B. AQC	3	0.0000			
Control R. AQC	3	0.0600			
H. AQC	3	0.0767			
B. AQC	4	0.0800			
Control A. AQC	3		0.4500		
Q. AQC	4		0.6500	0.6500	
R. AQC	4			0.9250	
A. AQC	4				1.3250
Sig.		0.651	0.206	0.086	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.333.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

CO_2 (%)

Duncan[a,b]

Air Quality Control of Workers' Industries	N	Subset for alpha = 0.05		
		1	2	3
Control H. AQC	3	4.0000		
Control R. AQC	3	11.2000	11.2000	
Control B. AQC	3	11.2000	11.2000	
Control Q. AQC	3		12.2000	
H. AQC	3		13.2667	
Q. AQC	4		13.8250	
R. AQC	4		14.1250	
Control A. AQC	3		15.2000	
A. AQC	4		17.8250	
B. AQC	4			29.2675
Sig.		0.057	0.105	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.333.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

CO, ppm

Duncana,b

Air Quality Control of Workers' Industries	N	Subset for alpha = 0.05 1	2	3	4
H. AQC	3	4.0000			
B. AQC	4	4.0000			
Control R. AQC	3	4.0000			
Control A. AQC	3	4.0000			
Control B. AQC	3	4.0000			
Control Q. AQC	3	6.0000	6.0000		
R. AQC	4	9.1750	9.1750		
Control H. AQC	3		11.2000		
Q. AQC	4			17.0000	
A. AQC	4				42.9000
Sig.		0.087	0.063	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.333.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

SO_2,ppm

Duncan[a,b]

Air Quality Control of Workers' Industries	N	Subset for alpha = 0.05 1	2	3
Control H. AQC	3	0.0000		
Control R. AQC	3	0.0000		
Control B. AQC	3	0.0100		
Control Q. AQC	3	0.3000	0.3000	
Control A. AQC	3	0.4000	0.4000	
H. AQC	3	0.8000	0.8000	
B. AQC	4	0.8000	0.8000	
R .AQC	4	1.0500	1.0500	
Q. AQC	4		1.1500	
A. AQC	4			4.7250
Sig.		0.066	0.127	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.333.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

VOC, ppm

Duncan a,b

Air Quality Control of Workers' Industries	N	Subset for alpha = 0.05 1	2	3
Control H AQC	3	0.0000		
Control R AQC	3	0.0000		
Control B AQC	3	0.0000		
Q AQC	4	0.2000		
R AQC	4	0.2000		
Control Q. AQC	3	0.2000		
B. AQC	4	0.4725		
H. AQC	3	0.5333		
Control A. AQC	3		3.0000	
A. AQC	4			6.4250
Sig.		0.493	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.333.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

PM10µg/m3

Duncan[a,b]

Air Quality Control of Workers' Industries	N	Subset for alpha = 0.05 1	2	3	4
Control B. AQC	3	4.3000			
B. AQC	4	5.1925			
H. AQC	3	5.5667			
Control H. AQC	3	5.6000			
Control R. AQC	3	30.6000	30.6000		
Control Q. AQC	3		40.6000	40.6000	
Control A. AQC	3		40.6000	40.6000	
Q. AQC	4			59.7000	
R. AQC	4			62.0000	
A. AQC	4				92.3500
Sig.		0.071	0.460	0.131	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.333.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

ONEWAY Temperature, pH, Conductivity, TDS, DO, BOD, NO3, NO3-N, PO4, P, Pb, Cd, Hg, As, Cr, by Physicochemical Analysis of Water

/STATISTICS DESCRIPTIVES HOMOGENEITY

/MISSING ANALYSIS

/POSTHOC=DUNCAN ALPHA(0.05).

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Temperature, °C	H. PCPW	3	29.2667	0.90185	0.52068	27.0263	31.5070	28.40	30.20
	Control H	3	27.2000	2.77849	1.60416	20.2979	34.1021	24.00	29.00
	Q. PCPW	3	33.2000	1.96977	1.13725	28.3068	38.0932	31.60	35.40
	Control Q	3	30.0000	2.64575	1.52753	23.4276	36.5724	27.00	32.00
	R. PCPW	3	28.7333	0.41633	0.24037	27.6991	29.7676	28.40	29.20
	Control R	3	27.4000	0.20000	0.11547	26.9032	27.8968	27.20	27.60
	A. PCPW	3	30.5000	2.19317	1.26623	25.0519	35.9481	28.90	33.00
	Control A	3	28.0000	1.00000	0.57735	25.5159	30.4841	27.00	29.00
	B. PCPW	3	27.1667	0.05774	0.03333	27.0232	27.3101	27.10	27.20
	Control B	3	27.0000	0.10000	0.05774	26.7516	27.2484	26.90	27.10
	Total	30	28.8467	2.31766	0.42314	27.9812	29.7121	24.00	35.40
pH	H. PCPW	3	8.0667	2.11370	1.22035	2.8159	13.3174	6.28	10.40
	Control H	3	6.3000	0.10000	0.05774	6.0516	6.5484	6.20	6.40
	Q. PCPW	3	7.0333	1.50444	0.86859	3.2961	10.7706	5.60	8.60
	Control Q	3	7.0300	0.01000	0.00577	7.0052	7.0548	7.02	7.04
	R. PCPW	3	6.8200	0.63530	0.36679	5.2418	8.3982	6.28	7.52
	Control R	3	6.0667	0.01528	0.00882	6.0287	6.1046	6.05	6.08
	A. PCPW	3	7.6233	2.45712	1.41862	1.5195	13.7272	5.73	10.40
	Control A	3	6.3800	0.45078	0.26026	5.2602	7.4998	6.10	6.90
	B. PCPW	3	6.5900	0.93000	0.53694	4.2798	8.9002	5.54	7.31
	Control B	3	6.0300	0.01732	0.01000	5.9870	6.0730	6.01	6.04
	Total	30	6.7940	1.18138	0.21569	6.3529	7.2351	5.54	10.40

Conductivity, µS/cm	H. PCPW	3	2658.0000	4505.07525	2601.00641	-8533.2273	13849.2273	47.00	7860.00
	Control H	3	10.0000	3.60555	2.08167	1.0433	18.9567	7.00	14.00
	Q. PCPW	3	6262.6667	10503.89053	6064.42403	-19830.4439	32355.7773	33.00	18390.00
	Control Q	3	1000.0000	100.00000	57.73503	751.5862	1248.4138	900.00	1100.00
	R. PCPW	3	55.3333	10.40833	6.00925	29.4776	81.1891	47.00	67.00
	Control R	3	10.0000	2.64575	1.52753	3.4276	16.5724	7.00	12.00
	A. PCPW	3	1300.7667	2030.64999	1172.39632	-3743.6475	6345.1809	84.30	3645.00
	Control A	3	80.0000	9.53939	5.50757	56.3028	103.6972	70.00	89.00
	B. PCPW	3	16.6667	5.77350	3.33333	2.3245	31.0088	10.00	20.00
	Control B	3	10.0000	0.50000	0.28868	8.7579	11.2421	9.50	10.50
	Total	30	1140.3433	3607.82153	658.69508	-206.8394	2487.5260	7.00	18390.00
TDS, mg/l	H. PCPW	3	1596.7000	2701.40086	1559.65451	-5113.9518	8307.3518	30.55	4716.00
	Control H	3	6.5000	0.26458	0.15275	5.8428	7.1572	6.20	6.70
	Q. PCPW	3	484.6833	624.84217	360.75280	-1067.5107	2036.8773	21.45	1195.35
	Control Q	3	405.0000	2.64575	1.52753	398.4276	411.5724	402.00	407.00
	R. PCPW	3	35.9667	6.76541	3.90601	19.1604	52.7729	30.55	43.55
	Control R	3	6.5000	0.20000	0.11547	6.0032	6.9968	6.30	6.70
	A. PCPW	3	848.4967	1317.43270	760.62012	-2424.1876	4121.1809	54.79	2369.25
	Control A	3	46.5000	0.40000	0.23094	45.5063	47.4937	46.10	46.90
	B. PCPW	3	10.8333	3.75278	2.16667	1.5109	20.1557	6.50	13.00
	Control B	3	6.5000	0.10000	0.05774	6.2516	6.7484	6.40	6.60
	Total	30	344.7680	952.26686	173.85935	-10.8143	700.3503	6.20	4716.00

DO, mg/l	H. PCPW	3	3.9667	0.85049	0.49103	1.8539	6.0794	3.00	4.60
	Control H	3	4.0000	1.00000	0.57735	1.5159	6.4841	3.00	5.00
	Q. PCPW	3	3.5667	1.66533	0.96148	-0.5702	7.7036	1.70	4.90
	Control Q	3	4.8000	0.10000	0.05774	4.5516	5.0484	4.70	4.90
	R. PCPW	3	3.5667	0.89629	0.51747	1.3402	5.7932	3.00	4.60
	Control R	3	4.8000	0.10000	0.05774	4.5516	5.0484	4.70	4.90
	A. PCPW	3	2.6667	1.58850	0.91712	-1.2794	6.6127	1.70	4.50
	Control A	3	4.8000	0.17321	0.10000	4.3697	5.2303	4.60	4.90
	B. PCPW	3	5.0667	0.15275	0.08819	4.6872	5.4461	4.90	5.20
	Control B	3	4.8000	0.36056	0.20817	3.9043	5.6957	4.40	5.10
	Total	30	4.2033	1.05650	0.19289	3.8088	4.5978	1.70	5.20
BOD, mg/l	H. PCPW	3	4.4000	3.38674	1.95533	-4.0131	12.8131	2.20	8.30
	Control H	3	0.8000	0.10000	0.05774	0.5516	1.0484	0.70	0.90
	Q. PCPW	3	1.9000	0.78102	0.45092	-0.0402	3.8402	1.00	2.40
	Control Q	3	0.4700	0.31575	0.18230	-0.3144	1.2544	0.11	0.70
	R. PCPW	3	2.4000	0.26458	0.15275	1.7428	3.0572	2.20	2.70
	Control R	3	0.8000	0.17321	0.10000	0.3697	1.2303	0.60	0.90
	A. PCPW	3	1.6000	0.70000	0.40415	-0.1389	3.3389	0.90	2.30
	Control A	3	0.8000	0.10000	0.05774	0.5516	1.0484	0.70	0.90
	B. PCPW	3	1.9667	1.02632	0.59255	-0.5829	4.5162	1.10	3.10
	Control B	3	0.8000	0.10000	0.05774	0.5516	1.0484	0.70	0.90
	Total	30	1.5937	1.50091	0.27403	1.0332	2.1541	0.11	8.30

DO, mg/l	H. PCPW	3	3.9667	0.85049	0.49103	1.8539	6.0794	3.00	4.60
	Control H	3	4.0000	1.00000	0.57735	1.5159	6.4841	3.00	5.00
	Q. PCPW	3	3.5667	1.66533	0.96148	-0.5702	7.7036	1.70	4.90
	Control Q	3	4.8000	0.10000	0.05774	4.5516	5.0484	4.70	4.90
	R. PCPW	3	3.5667	0.89629	0.51747	1.3402	5.7932	3.00	4.60
	Control R	3	4.8000	0.10000	0.05774	4.5516	5.0484	4.70	4.90
	A. PCPW	3	2.6667	1.58850	0.91712	-1.2794	6.6127	1.70	4.50
	Control A	3	4.8000	0.17321	0.10000	4.3697	5.2303	4.60	4.90
	B. PCPW	3	5.0667	0.15275	0.08819	4.6872	5.4461	4.90	5.20
	Control B	3	4.8000	0.36056	0.20817	3.9043	5.6957	4.40	5.10
	Total	30	4.2033	1.05650	0.19289	3.8088	4.5978	1.70	5.20
BOD, mg/l	H. PCPW	3	4.4000	3.38674	1.95533	-4.0131	12.8131	2.20	8.30
	Control H	3	0.8000	0.10000	0.05774	0.5516	1.0484	0.70	0.90
	Q. PCPW	3	1.9000	0.78102	0.45092	-0.0402	3.8402	1.00	2.40
	Control Q	3	0.4700	0.31575	0.18230	-0.3144	1.2544	0.11	0.70
	R. PCPW	3	2.4000	0.26458	0.15275	1.7428	3.0572	2.20	2.70
	Control R	3	0.8000	0.17321	0.10000	0.3697	1.2303	0.60	0.90
	A. PCPW	3	1.6000	0.70000	0.40415	-0.1389	3.3389	0.90	2.30
	Control A	3	0.8000	0.10000	0.05774	0.5516	1.0484	0.70	0.90
	B. PCPW	3	1.9667	1.02632	0.59255	-0.5829	4.5162	1.10	3.10
	Control B	3	0.8000	0.10000	0.05774	0.5516	1.0484	0.70	0.90
	Total	30	1.5937	1.50091	0.27403	1.0332	2.1541	0.11	8.30

PO4-3, mg/l	H. PCPW	3	14.9000	5.35070	3.08923	1.6081	28.1919	9.50	20.20
	Control H	3	10.2000	1.05357	0.60828	7.5828	12.8172	9.20	11.30
	Q. PCPW	3	3.6667	3.80044	2.19418	-5.7741	13.1075	0.90	8.00
	Control Q	3	6.3000	0.26458	0.15275	5.6428	6.9572	6.10	6.60
	R. PCPW	3	11.0000	3.50000	2.02073	2.3055	19.6945	8.50	15.00
	Control R	3	10.3000	0.10000	0.05774	10.0516	10.5484	10.20	10.40
	A. PCPW	3	4.1333	5.12868	2.96104	-8.6070	16.8737	0.50	10.00
	Control A	3	10.3000	0.10000	0.05774	10.0516	10.5484	10.20	10.40
	B. PCPW	3	5.9500	8.22967	4.75140	-14.4936	26.3936	1.00	15.45
	Control B	3	10.3000	0.10000	0.05774	10.0516	10.5484	10.20	10.40
	Total	30	8.7050	4.70012	0.85812	6.9499	10.4601	0.50	20.20
P, mg/l	H. PCPW	3	4.7900	1.68502	0.97285	0.6042	8.9758	3.10	6.47
	Control H	3	3.3000	0.26458	0.15275	2.6428	3.9572	3.10	3.60
	Q. PCPW	3	1.3333	1.09697	0.63333	-1.3917	4.0583	0.70	2.60
	Control Q	3	3.3000	0.10000	0.05774	3.0516	3.5484	3.20	3.40
	R. PCPW	3	3.5667	1.07858	0.62272	0.8873	6.2460	2.80	4.80
	Control R	3	3.5000	0.45826	0.26458	2.3616	4.6384	3.00	3.90
	A. PCPW	3	1.3333	1.62891	0.94045	-2.7131	5.3798	0.20	3.20
	Control A	3	3.3000	0.17321	0.10000	2.8697	3.7303	3.20	3.50
	B. PCPW	3	1.9500	2.68514	1.55027	-4.7203	8.6203	0.35	5.05
	Control B	3	3.3000	0.30000	0.17321	2.5548	4.0452	3.00	3.60
	Total	30	2.9673	1.47749	0.26975	2.4156	3.5190	0.20	6.47

Pb, mg/l	H. PCPW	3	1.8577	1.91754	1.10709	-2.9058	6.6211	0.21	3.96
	Control H	3	1.0540	0.00361	0.00208	1.0450	1.0630	1.05	1.06
	Q. PCPW	3	0.2263	0.13925	0.08040	-0.1196	0.5722	0.07	0.32
	Control Q	3	1.0540	0.00173	0.00100	1.0497	1.0583	1.05	1.06
	R. PCPW	3	0.1223	0.01405	0.00811	0.0874	0.1572	0.11	0.14
	Control R	3	0.1030	0.00361	0.00208	0.0940	0.1120	0.10	0.11
	A. PCPW	3	0.3033	0.01976	0.01141	0.2543	0.3524	0.28	0.32
	Control A	3	0.0540	0.00100	0.00058	0.0515	0.0565	0.05	0.06
	B. PCPW	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Control B	3	1.0540	0.00100	0.00058	1.0515	1.0565	1.05	1.06
	Total	30	0.5829	0.78933	0.14411	0.2881	0.8776	0.00	3.96
Cd, mg/l	H. PCPW	3	0.1720	0.09891	0.05711	-0.0737	0.4177	0.11	0.29
	Control H	3	0.1030	0.00200	0.00115	0.0980	0.1080	0.10	0.11
	Q. PCPW	3	0.1310	0.00656	0.00379	0.1147	0.1473	0.13	0.14
	Control Q	3	0.1010	0.00100	0.00058	0.0985	0.1035	0.10	0.10
	R. PCPW	3	1.4723	2.15619	1.24488	-3.8839	6.8286	0.21	3.96
	Control R	3	1.0540	0.00100	0.00058	1.0515	1.0565	1.05	1.06
	A. PCPW	3	0.0937	0.01332	0.00769	0.0606	0.1267	0.08	0.11
	Control A	3	0.1030	0.00265	0.00153	0.0964	0.1096	0.10	0.11
	B. PCPW	3	0.0087	0.01501	0.00867	-0.0286	0.0460	0.00	0.03
	Control B	3	0.1030	0.00100	0.00058	0.1005	0.1055	0.10	0.10
	Total	30	0.3342	0.74505	0.13603	0.0560	0.6124	0.00	3.96
Hg, mg/l	H. PCPW	3	0.1033	0.06806	0.03930	-0.0657	0.2724	0.03	0.15
	Control H	3	0.1030	0.00265	0.00153	0.0964	0.1096	0.10	0.11
	Q. PCPW	3	0.1433	0.02871	0.01658	0.0720	0.2147	0.12	0.18
	Control Q	3	0.1130	0.00265	0.00153	0.1064	0.1196	0.11	0.12
	R. PCPW	3	0.1433	0.00569	0.00328	0.1292	0.1575	0.14	0.15
	Control R	3	0.1130	0.00100	0.00058	0.1105	0.1155	0.11	0.11
	A. PCPW	3	0.1277	0.01626	0.00939	0.0873	0.1681	0.12	0.15
	Control A	3	0.1130	0.00265	0.00153	0.1064	0.1196	0.11	0.12
	B. PCPW	3	0.0073	0.01102	0.00636	-0.0200	0.0347	0.00	0.02
	Control B	3	0.1130	0.00100	0.00058	0.1105	0.1155	0.11	0.11
	Total	30	0.1080	0.04205	0.00768	0.0923	0.1237	0.00	0.18

As, mg/l	H. PCPW	3	0.1333	0.10401	0.06005	-0.1250	0.3917	0.02	0.22
	Control H	3	0.0050	0.00173	0.00100	0.0007	0.0093	0.00	0.01
	Q. PCPW	3	0.0227	0.01457	0.00841	-0.0135	0.0589	0.01	0.03
	Control Q	3	0.0050	0.00346	0.00200	-0.0036	0.0136	0.00	0.01
	R. PCPW	3	0.0900	0.01000	0.00577	0.0652	0.1148	0.08	0.10
	Control R	3	0.0130	0.00100	0.00058	0.0105	0.0155	0.01	0.01
	A. PCPW	3	0.0230	0.00361	0.00208	0.0140	0.0320	0.02	0.03
	Control A	3	0.0150	0.00100	0.00058	0.0125	0.0175	0.01	0.02
	B. PCPW	3	0.1840	0.23301	0.13453	-0.3948	0.7628	0.00	0.45
	Control B	3	0.0050	0.00173	0.00100	0.0007	0.0093	0.00	0.01
	Total	30	0.0496	0.09113	0.01664	0.0156	0.0836	0.00	0.45
Cr, mg/l	H. PCPW	3	0.1170	0.13586	0.07844	-0.2205	0.4545	0.00	0.27
	Control H	3	0.2550	0.00361	0.00208	0.2460	0.2640	0.25	0.26
	Q. PCPW	3	0.0923	0.03055	0.01764	0.0164	0.1682	0.06	0.12
	Control Q	3	0.5500	0.02646	0.01528	0.4843	0.6157	0.52	0.57
	R. PCPW	3	0.1593	0.09473	0.05469	-0.0760	0.3947	0.09	0.27
	Control R	3	0.3550	0.00265	0.00153	0.3484	0.3616	0.35	0.36
	A. PCPW	3	0.0970	0.02128	0.01229	0.0441	0.1499	0.08	0.12
	Control A	3	0.3550	0.00265	0.00153	0.3484	0.3616	0.35	0.36
	B. PCPW	3	0.0073	0.01102	0.00636	-0.0200	0.0347	0.00	0.02
	Control B	3	0.3550	0.00100	0.00058	0.3525	0.3575	0.35	0.36
	Total	30	0.2343	0.16820	0.03071	0.1715	0.2971	0.00	0.57

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Temperature, °C	5.377	9	20	0.001
pH	5.258	9	20	0.001
Conductivity, µS/cm	13.865	9	20	0.000
TDS, mg/l	13.532	9	20	0.000
DO, mg/l	4.820	9	20	0.002
BOD, mg/l	9.902	9	20	0.000
NO3-, mg/l	13.926	9	20	0.000
NO3- N, mg/l	14.002	9	20	0.000
PO4-3, mg/l	5.883	9	20	0.000
P, mg/l	5.103	9	20	0.001
Pb, mg/l	7.985	9	20	0.000
Cd, mg/l	15.755	9	20	0.000
Hg, mg/l	10.115	9	20	0.000
As, mg/l	9.118	9	20	0.000
Cr, mg/l	6.228	9	20	0.000

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Temperature, °C	Between Groups	104.875	9	11.653	4.579	0.002
	Within Groups	50.900	20	2.545		
	Total	155.775	29			
pH	Between Groups	11.973	9	1.330	0.933	0.518
	Within Groups	28.502	20	1.425		
	Total	40.474	29			
Conductivity, µS/cm	Between Groups	107952486.227	9	11994720.692	0.890	0.551
	Within Groups	269522423.227	20	13476121.161		
	Total	377474909.454	29			
TDS, mg/l	Between Groups	7450171.923	9	827796.880	0.878	0.560
	Within Groups	18847380.819	20	942369.041		
	Total	26297552.742	29			
DO, mg/l	Between Groups	16.316	9	1.813	2.259	0.062
	Within Groups	16.053	20	0.803		
	Total	32.370	29			

BOD, mg/l	Between Groups	37.623	9	4.180	3.018	0.019
	Within Groups	27.706	20	1.385		
	Total	65.329	29			
NO3-, mg/l	Between Groups	50427.380	9	5603.042	1.351	0.274
	Within Groups	82943.637	20	4147.182		
	Total	133371.017	29			
NO3- N, mg/l	Between Groups	2544.606	9	282.734	1.335	0.281
	Within Groups	4236.882	20	211.844		
	Total	6781.488	29			
PO4-3, mg/l	Between Groups	339.513	9	37.724	2.505	0.042
	Within Groups	301.128	20	15.056		
	Total	640.642	29			
P, mg/l	Between Groups	32.348	9	3.594	2.322	0.056
	Within Groups	30.959	20	1.548		
	Total	63.306	29			
Pb, mg/l	Between Groups	10.674	9	1.186	3.208	0.014
	Within Groups	7.394	20	0.370		
	Total	18.068	29			
Cd, mg/l	Between Groups	6.779	9	0.753	1.617	0.177
	Within Groups	9.319	20	0.466		
	Total	16.098	29			
Hg, mg/l	Between Groups	0.039	9	0.004	7.440	0.000
	Within Groups	0.012	20	0.001		
	Total	0.051	29			
As, mg/l	Between Groups	0.110	9	0.012	1.866	0.118
	Within Groups	0.131	20	0.007		
	Total	0.241	29			
Cr, mg/l	Between Groups	0.761	9	0.085	28.505	0.000
	Within Groups	0.059	20	0.003		
	Total	0.820	29			

Temperature, °C

Duncan[a]

Physiochemical Analysis of Water	N	Subset for alpha = 0.05		
		1	2	3
Control B	3	27.0000		
B. PCPW	3	27.1667		
Control H	3	27.2000		
Control R	3	27.4000		
Control A	3	28.0000	28.0000	
R. PCPW	3	28.7333	28.7333	
H. PCPW	3	29.2667	29.2667	
Control Q	3	30.0000	30.0000	
A. PCPW	3		30.5000	30.5000
Q. PCPW	3			33.2000
Sig.		0.057	0.099	0.051

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

pH

Duncan[a]

Physiochemical Analysis of Water	N	Subset for alpha = 0.05
		1
Control B	3	6.0300
Control R	3	6.0667
Control H	3	6.3000
Control A	3	6.3800
B. PCPW	3	6.5900
R. PCPW	3	6.8200
Control Q	3	7.0300
Q. PCPW	3	7.0333
A. PCPW	3	7.6233
H. PCPW	3	8.0667
Sig.		0.086

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Conductivity, µS/cm

Duncan[a]

Physiochemical Analysis of Water	N	Subset for alpha = 0.05
		1
Control H	3	10.0000
Control R	3	10.0000
Control B	3	10.0000
B. PCPW	3	16.6667
R. PCPW	3	55.3333
Control A	3	80.0000
Control Q	3	1000.0000
A. PCPW	3	1300.7667
H. PCPW	3	2658.0000
Q. PCPW	3	6262.6667
Sig.		0.086

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

TDS, mg/l

Duncan[a]

Physiochemical Analysis of Water	N	Subset for alpha = 0.05
		1
Control H	3	6.5000
Control R	3	6.5000
Control B	3	6.5000
B. PCPW	3	10.8333
R. PCPW	3	35.9667
Control A	3	46.5000
Control Q	3	405.0000
Q. PCPW	3	484.6833
A. PCPW	3	848.4967
H. PCPW	3	1596.7000
Sig.		0.098

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

DO, mg/l

Duncan[a]

Physiochemical Analysis of Water	N	Subset for alpha = 0.05	
		1	2
A. PCPW	3	2.6667	
Q. PCPW	3	3.5667	3.5667
R. PCPW	3	3.5667	3.5667
H. PCPW	3	3.9667	3.9667
Control H	3	4.0000	4.0000
Control Q	3		4.8000
Control A	3		4.8000
Control B	3		4.8000
Control R	3		4.8000
B. PCPW	3		5.0667
Sig.		0.116	0.090

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

BOD, mg/l

Duncan[a]

Physiochemical Analysis of Water	N	Subset for alpha = 0.05	
		1	2
Control Q	3	0.4700	
Control R	3	0.8000	
Control H	3	0.8000	
Control A	3	0.8000	
Control B	3	0.8000	
A. PCPW	3	1.6000	
Q. PCPW	3	1.9000	
B. PCPW	3	1.9667	
R. PCPW	3	2.4000	2.4000
H. PCPW	3		4.4000
Sig.		0.096	0.050

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

NO_3^-, mg/l

Duncan[a]

Physiochemical Analysis of Water	N	Subset for alpha = 0.05	
		1	2
A. PCPW	3	8.1667	
Control A	3	10.1000	
Control Q	3	14.1000	
Control R	3	14.1000	
Control B	3	14.1000	
Control H	3	15.1000	
B. PCPW	3	15.2667	
R. PCPW	3	27.8500	
Q. PCPW	3	30.6667	
H. PCPW	3		151.3833
Sig.		0.711	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

PO_4^{-3}, mg/l

Duncan[a]

Physiochemical Analysis of Water	N	Subset for alpha = 0.05	
		1	2
Q. PCPW	3	3.6667	
A. PCPW	3	4.1333	
B. PCPW	3	5.9500	
Control Q	3	6.3000	
Control H	3	10.2000	10.2000
Control R	3	10.3000	10.3000
Control A	3	10.3000	10.3000
Control B	3	10.3000	10.3000
R. PCPW	3	11.0000	11.0000
H. PCPW	3		14.9000
Sig.		0.058	0.203

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

P, mg/l

Duncan[a]

Physiochemical Analysis of Water	N	Subset for alpha = 0.05	
		1	2
Q. PCPW	3	1.3333	
A. PCPW	3	1.3333	
B. PCPW	3	1.9500	
Control Q	3	3.3000	3.3000
Control H	3	3.3000	3.3000
Control A	3	3.3000	3.3000
Control B	3	3.3000	3.3000
Control R	3	3.5000	3.5000
R. PCPW	3	3.5667	3.5667
H. PCPW	3		4.7900
Sig.		0.070	0.212

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Pb, mg/l

Duncan[a]

PhysiochemicalAnalysisofIndustriesWater	N	Subset for alpha = 0.05	
		1	2
B. PCPW	3	0.0000	
Control A	3	0.0540	
Control R	3	0.1030	
R. PCPW	3	0.1223	
Q. PCPW	3	0.2263	
A. PCPW	3	0.3033	
Control H	3	1.0540	1.0540
Control Q	3	1.0540	1.0540
Control B	3	1.0540	1.0540
H. PCPW	3		1.8577
Sig.		0.080	0.152

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Cd, mg/l

Duncan[a]

PhysiochemicalAnalysisofIndustriesWater	N	Subset for alpha = 0.05 1	2
B. PCPW	3	0.0087	
A. PCPW	3	0.0937	
Control Q	3	0.1010	
Control H	3	0.1030	
Control A	3	0.1030	
Control B	3	0.1030	
Q. PCPW	3	0.1310	
H. PCPW	3	0.1720	
Control R	3	1.0540	1.0540
R. PCPW	3		1.4723
Sig.		0.119	0.462

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Hg, mg/l

Duncan[a]

PhysiochemicalAnalysisofIndustriesWater	N	Subset for alpha = 0.05 1	2
B. PCPW	3	0.0073	
Control H	3		0.1030
H. PCPW	3		0.1033
Control Q	3		0.1130
Control R	3		0.1130
Control A	3		0.1130
Control B	3		0.1130
A. PCPW	3		0.1277
Q. PCPW	3		0.1433
R. PCPW	3		0.1433
Sig.		1.000	0.092

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

As, mg/l

Duncan[a]

PhysiochemicalAnalysisofIndustriesWater	N	Subset for alpha = 0.05	
		1	2
Control H	3	0.0050	
Control Q	3	0.0050	
Control B	3	0.0050	
Control R	3	0.0130	
Control A	3	0.0150	
Q. PCPW	3	0.0227	
A. PCPW	3	0.0230	
R. PCPW	3	0.0900	0.0900
H. PCPW	3	0.1333	0.1333
B. PCPW	3		0.1840
Sig.		0.107	0.193

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Cr, mg/l

Duncan[a]

Physiochemical Analysis of Industries Water	N	Subset for alpha = 0.05			
		1	2	3	4
B. PCPW	3	0.0073			
Q. PCPW	3	0.0923	0.0923		
A. PCPW	3	0.0970	0.0970		
H. PCPW	3		0.1170		
R. PCPW	3		0.1593		
Control H	3			0.2550	
Control R	3			0.3550	
Control A	3			0.3550	
Control B	3			0.3550	
Control Q	3				0.5500
Sig.		0.069	0.182	0.051	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Statistical analysis

ONEWAY TBC, TPHB, TFC, TPH by Microbiological Water Analysis of Industries

STATISTICS DESCRIPTIVES HOMOGENEITY

/MISSING ANALYSIS

/POSTHOC=DUNCAN ALPHA(0.05).

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
TBC, CFU/ml	H. PCPW	3	286762	300751.349	173638.8723	-460345.7679	1033869.768	286	600000
	Control H	3	580	393.95431	227.44963	-398.6368	1558.6368	140	900
	Q. PCPW	2	850000	919238.8155	650000	-7409033.079	9109033.079	200000	1.50E+06
	Control Q	3	1000	200	115.47005	503.1725	1496.8275	800	1200
	R. PCPW	3	313333.333	264070.6976	152461.2884	-342654.6452	969321.3118	80000	600000
	Control R	3	1000	360.55513	208.1666	104.3314	1895.6686	700	1400
	A. PCPW	4	733000	659228.8424	329614.4212	-315980.1969	1781980.197	2000	1.60E+06
	Control A	3	1000	200	115.47005	503.1725	1496.8275	800	1200
	B. PCPW	3	530000	455741.1546	263122.2783	-602123.7889	1662123.789	10000	860000
	Control B	3	966.6667	152.75252	88.19171	587.2084	1346.125	800	1100
	Total	30	267864.2	443733.4079	81014.26568	102171.4224	433556.9776	140	1.60E+06
THUB, CFU/ml	H. PCPW	3	4	6.9282	4	-13.2106	21.2106	0	12
	Control H	3	0	0	0	0	0	0	0
	Q. PCPW	2	4000	5656.85425	4000	-46824.8189	54824.8189	0	8000
	Control Q	3	0	0	0	0	0	0	0
	R. PCPW	3	0	0	0	0	0	0	0
	Control R	3	0	0	0	0	0	0	0
	A. PCPW	4	6300	6832.27634	3416.13817	-4571.6763	17171.6763	0	15000
	Control A	3	0	0	0	0	0	0	0
	B. PCPW	3	5666.6667	3055.05046	1763.83421	-1922.4994	13255.8327	3000	9000
	Control B	3	0	0	0	0	0	0	0
	Total	30	1673.7333	3684.81809	672.75266	297.7996	3049.667	0	15000
TFC, CFU/ml	H. PCPW	3	3303	4176.16175	2411.10811	-7071.1609	13677.1609	9	8000
	Control H	3	1000	100	57.73503	751.5862	1248.4138	900	1100
	Q. PCPW	2	525000	671751.4421	475000	-5510447.25	6560447.25	50000	1.00E+06
	Control Q	3	1000	300	173.20508	254.7587	1745.2413	700	1300
	R. PCPW	3	4733.3333	3073.00071	1774.19778	-2900.4236	12367.0903	1900	8000
	Control R	3	833.3333	152.75252	88.19171	453.875	1212.7916	700	1000
	A. PCPW	4	2075	2165.44838	1082.72419	-1370.7116	5520.7116	0	5000
	Control A	3	1000	300	173.20508	254.7587	1745.2413	700	1300
	B. PCPW	3	3666.6667	1154.70054	666.66667	798.2315	6535.1018	3000	5000
	Control B	3	1000	200	115.47005	503.1725	1496.8275	800	1200
	Total	30	36930.3	182116.5957	33249.78919	-31073.1544	104933.7544	0	1.00E+06
THUF, CFU/ml	H. PCPW	3	18	12.52996	7.23418	-13.1262	49.1262	5	30
	Control H	3	0	0	0	0	0	0	0
	Q. PCPW	2	1250	1767.76695	1250	-14632.7559	17132.7559	0	2500
	Control Q	3	0	0	0	0	0	0	0
	R. PCPW	3	16.3333	15.17674	8.76229	-21.3678	54.0344	0	30
	Control R	3	0	0	0	0	0	0	0
	A. PCPW	4	0	0	0	0	0	0	0
	Control A	3	0	0	0	0	0	0	0
	B. PCPW	3	300	100	57.73503	51.5862	548.4138	200	400
	Control B	3	0	0	0	0	0	0	0
	Total	30	116.7667	459.89179	83.96437	-54.9598	288.4931	0	2500

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
TBC, CFU/ml	4.107	9	20	0.004
THUB, CFU/ml	9.751	9	20	0.000
TFC, CFU/ml	63295.280	9	20	0.000
THUF, CFU/ml	934.602	9	20	0.000

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
TBC, CFU/ml	Between Groups	2.82556E+12	9	3.13951E+11	2.177	0.071
	Within Groups	2.88452E+12	20	1.44226E+11		
	Total	5.71008E+12	29			
THUB, CFU/ml	Between Groups	203051883.2	9	22561320.36	2.366	0.052
	Within Groups	190706762.7	20	9535338.133		
	Total	393758645.9	29			
TFC, CFU/ml	Between Groups	5.10506E+11	9	56722907798	2.514	0.041
	Within Groups	4.51321E+11	20	22566050408		
	Total	9.61827E+11	29			
THUF, CFU/ml	Between Groups	2987738.7	9	331970.967	2.111	0.079
	Within Groups	3145774.667	20	157288.733		
	Total	6133513.367	29			

Post Hoc Tests

Homogeneous Subsets

TBC, CFU/ml

Duncan[a]

Microbial Analysis of Industries Water	N	Subset for alpha = 0.05 1
Control H	3	580.0000
Control B	3	966.6667
Control Q	3	1000.0000
Control R	3	1000.0000
Control A	3	1000.0000
H. PCPW	3	286762.0000
R. PCPW	3	313333.3333
B. PCPW	3	530000.0000
Q. PCPW	3	568333.3333
A. PCPW	3	734000.0000
Sig.		0.073

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

TPHB, CFU/ml

Duncan[a]

MicrobialAnalysisofIndustriesWater	N	Subset for alpha = 0.05 1
Control H	3	0.0000
Control Q	3	0.0000
R. PCPW	3	0.0000
Control R	3	0.0000
Control A	3	0.0000
Control B	3	0.0000
H. PCPW	3	4.0000
Q. PCPW	3	3033.3333
A. PCPW	3	5600.0000
B. PCPW	3	5666.6667
Sig.		0.066

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

TFC, CFU/ml

Duncan[a]

MicrobialAnalysisofIndustriesWater	N	Subset for alpha = 0.05 1
Control R	3	833.3333
Control H	3	1000.0000
Control Q	3	1000.0000
Control A	3	1000.0000
Control B	3	1000.0000
A. PCPW	3	2000.0000
H. PCPW	3	3303.0000
B. PCPW	3	3666.6667
R. PCPW	3	4733.3333
Q. PCPW	3	350500.0000
Sig.		0.050

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

THUF, CFU/ml

Duncan[a]

MicrobialAnalysis of Water	N	Subset for alpha = 0.05 1
Control H	3	0.0000
Control Q	3	0.0000
Control R	3	0.0000
A. PCPW	3	0.0000
Control A	3	0.0000
Control B	3	0.0000
R. PCPW	3	16.3333
H. PCPW	3	18.0000
B. PCPW	3	300.0000
Q. PCPW	3	833.3333
Sig.		0.068

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

ONEWAY Sand Silt Clay Porosity by physical properties of soil samples of industries

/STATISTICS DESCRIPTIVES HOMOGENEITY

/MISSING ANALYSIS

/POSTHOC=DUNCAN ALPHA (0.05).

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Sand	H PPS	3	76.0000	.43589	.25166	74.9172	77.0828	75.50	76.30
	Q PPS	3	88.2000	.80000	.46188	86.2127	90.1873	87.40	89.00
	R PPS	3	76.4000	.60828	.35119	74.8890	77.9110	75.70	76.80
	A PPS	3	84.0000	3.00000	1.73205	76.5476	91.4524	81.00	87.00
	B PPS	3	71.0000	1.04403	.60277	68.4065	73.5935	69.80	71.70
	Control H	3	70.0000	2.64575	1.52753	63.4276	76.5724	68.00	73.00
	Control Q	3	82.0000	2.00000	1.15470	77.0317	86.9683	80.00	84.00
	Control R	3	75.4000	.10000	.05774	75.1516	75.6484	75.30	75.50
	Control A	3	82.0000	2.64575	1.52753	75.4276	88.5724	79.00	84.00
	Control B	3	72.0000	2.64575	1.52753	65.4276	78.5724	70.00	75.00
	Total	30	77.7000	6.08271	1.11055	75.4287	79.9713	68.00	89.00
Silt	H PPS	3	8.2000	.36056	.20817	7.3043	9.0957	7.80	8.50
	Q PPS	3	6.5000	.20000	.11547	6.0032	6.9968	6.30	6.70
	R PPS	3	8.4000	.52915	.30551	7.0855	9.7145	7.80	8.80
	A PPS	3	14.0000	3.60555	2.08167	5.0433	22.9567	10.00	17.00
	B PPS	3	6.1000	.36056	.20817	5.2043	6.9957	5.70	6.40
	Control H	3	7.2000	.36056	.20817	6.3043	8.0957	6.90	7.60
	Control Q	3	6.1000	.20000	.11547	5.6032	6.5968	5.90	6.30

	Control R	3	8.3000	.20000	.11547	7.8032	8.7968	8.10	8.50
	Control A	3	13.0000	1.00000	.57735	10.5159	15.4841	12.00	14.00
	Control B	3	8.6667	1.52753	.88192	4.8721	12.4612	7.00	10.00
	Total	30	8.6467	2.86016	.52219	7.5787	9.7147	5.70	17.00
	H PPS	3	15.3000	.87178	.50332	13.1344	17.4656	14.30	15.90
	Q PPS	3	3.7000	.20000	.11547	3.2032	4.1968	3.50	3.90
	R PPS	3	15.1000	.20000	.11547	14.6032	15.5968	14.90	15.30
	A PPS	3	8.0000	1.00000	.57735	5.5159	10.4841	7.00	9.00
	B PPS	3	21.8000	.10000	.05774	21.5516	22.0484	21.70	21.90
Clay	Control H	3	14.4000	.20000	.11547	13.9032	14.8968	14.20	14.60
	Control Q	3	3.2000	.20000	.11547	2.7032	3.6968	3.00	3.40
	Control R	3	14.9333	.15275	.08819	14.5539	15.3128	14.80	15.10
	Control A	3	8.0000	1.00000	.57735	5.5159	10.4841	7.00	9.00
	Control B	3	22.0000	1.00000	.57735	19.5159	24.4841	21.00	23.00
	Total	30	12.6433	6.49454	1.18574	10.2182	15.0684	3.00	23.00
	H PPS	3	27.6667	1.52753	.88192	23.8721	31.4612	26.00	29.00
	Q PPS	3	39.8000	.79373	.45826	37.8283	41.7717	38.90	40.40
	R PPS	3	32.0000	2.64575	1.52753	25.4276	38.5724	30.00	35.00
	A PPS	3	36.0000	4.35890	2.51661	25.1719	46.8281	31.00	39.00
	B PPS	3	52.0000	2.00000	1.15470	47.0317	56.9683	50.00	54.00
Porosity	Control H	3	30.0000	1.00000	.57735	27.5159	32.4841	29.00	31.00
	Control Q	3	40.0000	1.00000	.57735	37.5159	42.4841	39.00	41.00
	Control R	3	36.0000	3.60555	2.08167	27.0433	44.9567	32.00	39.00
	Control A	3	40.0000	1.00000	.57735	37.5159	42.4841	39.00	41.00
	Control B	3	50.0000	1.00000	.57735	47.5159	52.4841	49.00	51.00
	Total	30	38.3467	7.86607	1.43614	35.4094	41.2839	26.00	54.00

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Sand	2.467	9	20	.044
Silt	5.623	9	20	.001
Clay	2.092	9	20	.081
Porosity	3.209	9	20	.014

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Sand	Between Groups	1000.380	9	111.153	30.621	.000
	Within Groups	72.600	20	3.630		
	Total	1072.980	29			
Silt	Between Groups	202.988	9	22.554	13.172	.000
	Within Groups	34.247	20	1.712		
	Total	237.235	29			
Clay	Between Groups	1215.287	9	135.032	341.565	.000
	Within Groups	7.907	20	.395		
	Total	1223.194	29			
Porosity	Between Groups	1694.448	9	188.272	37.682	.000
	Within Groups	99.927	20	4.996		
	Total	1794.375	29			

Post Hoc Tests

Homogeneous Subsets

Sand

Duncan[a]

Physical properties of soil (PPS) samples of industries	N	Subset for alpha = 0.05			
		1	2	3	4
Control H	3	70.0000			
B PPS	3	71.0000			
Control B	3	72.0000			
Control R	3		75.4000		
H PPS	3		76.0000		
R PPS	3		76.4000		
Control Q	3			82.0000	
Control A	3			82.0000	
A PPS	3			84.0000	
N	3				88.2000
Sig.		.238	.551	.238	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Silt

Duncan[a]

Physical properties of soil (PPS) samples of industries	N	Subset for alpha = 0.05		
		1	2	3
Control Q	3	6.1000		
B PPS	3	6.1000		
Q PPS	3	6.5000	6.5000	
Control H	3	7.2000	7.2000	
H PPS	3	8.2000	8.2000	
Control R	3	8.3000	8.3000	
R PPS	3	8.4000	8.4000	
Control B	3		8.6667	
Control A	3			13.0000
A PPS	3			14.0000
Sig.		.072	.086	.360

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Clay

Duncan[a]

Physical properties of soil (PPS)\ samples of industries	N	Subset for alpha = 0.05			
		1	2	3	4
Control Q.	3	3.2000			
Q. PPS	3	3.7000			
A. PPS	3		8.0000		
Control A.	3		8.0000		
Control H.	3			14.4000	
Control R.	3			14.9333	
R. PPS	3			15.1000	
H. PPS	3			15.3000	
B PPS	3				21.8000
Control B.	3				22.0000
Sig.		.342	1.000	.122	.701

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Porosity

Duncan[a]

Physical properties of soil (PPS) samples of industries	N	Subset for alpha = 0.05			
		1	2	3	4
Healthcare PPS	3	27.6667			
Control Healthcare	3	30.0000	30.0000		
R. PPS	3		32.0000		
A. PPS	3			36.0000	
Control R.	3			36.0000	
Q. PPS	3			39.8000	
Control Q	3			40.0000	
Control A.	3			40.0000	
Control B.	3				50.0000
B. PPS	3				52.0000
Sig.		.216	.286	.061	.286

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Statistical analysis

ONEWAY pH, Pb, Cd, Hg, As, Cr by Soil PhysiochemicalAnalysis of Industries
STATISTICS DESCRIPTIVES HOMOGENEITY
/MISSING ANALYSIS
/POSTHOC=DUNCAN ALPHA(0.05).

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Lower Bound	95% Confidence Upper Bound	Minimum	Maximum
pH	H. soil	3	6.5400	0.01000	0.00577	6.5152	6.5648	6.53	6.55
	Control H	3	6.9700	0.02646	0.01528	6.9043	7.0357	6.94	6.99
	Q. soil	3	6.2900	0.02646	0.01528	6.2243	6.3557	6.27	6.32
	Control Q	3	6.9500	0.03000	0.01732	6.8755	7.0245	6.92	6.98
	R. soil	3	7.0500	0.02000	0.01155	7.0003	7.0997	7.03	7.07
	Control R	3	6.9500	0.04000	0.02309	6.8506	7.0494	6.91	6.99
	A. soil	3	1.9600	0.02000	0.01155	1.9103	2.0097	1.94	1.98
	Control A	3	6.9500	0.03000	0.01732	6.8755	7.0245	6.92	6.98
	B. soil	3	7.4500	0.01000	0.00577	7.4252	7.4748	7.44	7.46
	Control B	3	6.9500	0.03000	0.01732	6.8755	7.0245	6.92	6.98
	Total	30	6.4060	1.53609	0.28045	5.8324	6.9796	1.94	7.46
Pb mg/kg	H. soil	3	0.7280	0.00100	0.00058	0.7255	0.7305	0.73	0.73
	Control H	3	0.1053	0.00058	0.00033	0.1039	0.1068	0.11	0.11
	Q. soil	3	1.3940	0.00265	0.00153	1.3874	1.4006	1.39	1.40
	Control Q	3	0.1057	0.00058	0.00033	0.1042	0.1071	0.11	0.11
	R. soil	3	1.6300	0.01000	0.00577	1.6052	1.6548	1.62	1.64
	Control R	3	1.0540	0.00200	0.00115	1.0490	1.0590	1.05	1.06
	A. soil	3	0.4510	0.00100	0.00058	0.4485	0.4535	0.45	0.45
	Control A	3	0.0540	0.00100	0.00058	0.0515	0.0565	0.05	0.06
	B. soil	3	0.5360	0.01000	0.00577	0.5112	0.5608	0.53	0.55
	Control B	3	0.0540	0.00100	0.00058	0.0515	0.0565	0.05	0.06
	Total	30	0.6112	0.55934	0.10212	0.4023	0.8201	0.05	1.64
Cd, mg/kg	H. soil	3	0.1380	0.00100	0.00058	0.1355	0.1405	0.14	0.14
	Control H	3	0.0517	0.00058	0.00033	0.0502	0.0531	0.05	0.05
	Q. soil	3	0.0870	0.00100	0.00058	0.0845	0.0895	0.09	0.09
	Control Q	3	0.0520	0.00000	0.00000	0.0520	0.0520	0.05	0.05
	R. soil	3	0.1300	0.01000	0.00577	0.1052	0.1548	0.12	0.14
	Control R	3	0.1170	0.00200	0.00115	0.1120	0.1220	0.12	0.12
	A. soil	3	0.1040	0.00200	0.00115	0.0990	0.1090	0.10	0.11
	Control A	3	0.1170	0.00100	0.00058	0.1145	0.1195	0.12	0.12
	B. soil	3	0.1340	0.00200	0.00115	0.1290	0.1390	0.13	0.14
	Control B	3	0.1170	0.00200	0.00115	0.1120	0.1220	0.12	0.12
	Total	30	0.1048	0.03059	0.00558	0.0933	0.1162	0.05	0.14

Hg, mg/kg	H. soil	3	0.1100	0.01000	0.00577	0.0852	0.1348	0.10	0.12
	Control H	3	0.1140	0.00100	0.00058	0.1115	0.1165	0.11	0.12
	Q. soil	3	0.0700	0.01732	0.01000	0.0270	0.1130	0.06	0.09
	Control Q	3	0.1140	0.00200	0.00115	0.1090	0.1190	0.11	0.12
	R. soil	3	0.1053	0.00404	0.00233	0.0953	0.1154	0.10	0.11
	Control R	3	0.1140	0.00100	0.00058	0.1115	0.1165	0.11	0.12
	A. soil	3	0.1120	0.00100	0.00058	0.1095	0.1145	0.11	0.11
	Control A	3	0.1140	0.00200	0.00115	0.1090	0.1190	0.11	0.12
	B. soil	3	0.1160	0.00200	0.00115	0.1110	0.1210	0.11	0.12
	Control B	3	0.1140	0.00200	0.00115	0.1090	0.1190	0.11	0.12
	Total	30	0.1083	0.01440	0.00263	0.1030	0.1137	0.06	0.12
As, mg/kg	H. soil	3	0.2800	0.01000	0.00577	0.2552	0.3048	0.27	0.29
	Control H	3	0.0020	0.00100	0.00058	-0.0005	0.0045	0.00	0.00
	Q. soil	3	0.0190	0.00200	0.00115	0.0140	0.0240	0.02	0.02
	Control Q	3	0.0020	0.00100	0.00058	-0.0005	0.0045	0.00	0.00
	R. soil	3	0.1950	0.00265	0.00153	0.1884	0.2016	0.19	0.20
	Control R	3	0.1850	0.00200	0.00115	0.1800	0.1900	0.18	0.19
	A. soil	3	0.0445	0.00042	0.00024	0.0434	0.0455	0.04	0.04
	Control A	3	0.0020	0.00100	0.00058	-0.0005	0.0045	0.00	0.00
	B. soil	3	0.0040	0.00100	0.00058	0.0015	0.0065	0.00	0.01
	Control B	3	0.0020	0.00100	0.00058	-0.0005	0.0045	0.00	0.00
	Total	30	0.0735	0.10120	0.01848	0.0358	0.1113	0.00	0.29
Cr, mg/kg	H. soil	3	0.1530	0.00900	0.00520	0.1306	0.1754	0.14	0.16
	Control H	3	0.0187	0.00058	0.00033	0.0172	0.0201	0.02	0.02
	Q. soil	3	0.0770	0.00100	0.00058	0.0745	0.0795	0.08	0.08
	Control Q	3	0.1850	0.00200	0.00115	0.1800	0.1900	0.18	0.19
	R. soil	3	0.1200	0.02646	0.01528	0.0543	0.1857	0.09	0.14
	Control R	3	0.1900	0.01000	0.00577	0.1652	0.2148	0.18	0.20
	A. soil	3	0.0112	0.00000	0.00000	0.0112	0.0112	0.01	0.01
	Control A	3	0.1850	0.00300	0.00173	0.1775	0.1925	0.18	0.19
	B. soil	3	0.0920	0.00100	0.00058	0.0895	0.0945	0.09	0.09
	Control B	3	0.1850	0.00200	0.00115	0.1800	0.1900	0.18	0.19
	Total	30	0.1217	0.06745	0.01231	0.0965	0.1469	0.01	0.20

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
pH	0.640	9	20	0.750
Pb mg/kg	2.649	9	20	0.033
Cd, mg/kg	2.705	9	20	0.031
Hg, mg/kg	6.408	9	20	0.000
As, mg/kg	2.747	9	20	0.029
Cr, mg/kg	6.721	9	20	0.000

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
pH	Between Groups	68.415	9	7.602	11345.692	0.000
	Within Groups	0.013	20	0.001		
	Total	68.428	29			
Pb mg/kg	Between Groups	9.073	9	1.008	46741.440	0.000
	Within Groups	0.000	20	0.000		
	Total	9.073	29			
Cd, mg/kg	Between Groups	0.027	9	0.003	250.416	0.000
	Within Groups	0.000	20	0.000		
	Total	0.027	29			
Hg, mg/kg	Between Groups	0.005	9	0.001	13.124	0.000
	Within Groups	0.001	20	0.000		
	Total	0.006	29			
As, mg/kg	Between Groups	0.297	9	0.033	2744.069	0.000
	Within Groups	0.000	20	0.000		
	Total	0.297	29			
Cr, mg/kg	Between Groups	0.130	9	0.014	160.587	0.000
	Within Groups	0.002	20	0.000		
	Total	0.132	29			

Post Hoc Tests

Homogeneous Subsets

pH

Duncan[a]

Chemical Soil Analysis of Industries	N	Subset for alpha = 0.05 1	2	3	4	5	6
A. soil	3	1.9600					
Q. soil	3		6.2900				
H. soil	3			6.5400			
Control Q	3				6.9500		
Control R	3				6.9500		
Control A	3				6.9500		
Control B	3				6.9500		
Control H	3				6.9700		
R. soil	3					7.0500	
B. soil	3						7.4500
Sig.		1.000	1.000	1.000	0.406	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Pb mg/kg

Duncan[a]

Physiochemical Soil Analysis of Industries	N	Subset for alpha = 0.05 1	2	3	4	5	6	7	8
Control A.	3	0.0540							
Control B.	3	0.0540							
Control H.	3		0.1053						
Control Q.	3		0.1057						
A. soil	3			0.4510					
B. soil	3				0.5360				
H. soil	3					0.7280			
Control R	3						1.0540		
Q. soil	3							1.3940	
R. soil	3								1.6300
Sig.		1.000	0.931	1.000	1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Cd, mg/kg

Duncan[a]

Chemical Soil Analysis of Industries	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
Control H.	3	0.0517					
Control Q.	3	0.0520					
Q. soil	3		0.0870				
A. soil	3			0.1040			
Control R.	3				0.1170		
Control A.	3				0.1170		
Control B.	3				0.1170		
R. soil	3					0.1300	
B. soil	3					0.1340	0.1340
H. soil	3						0.1380
Sig.		0.907	1.000	1.000	1.000	0.172	0.172

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Hg, mg/kg

Duncan[a]

ChemicalAnalysisofIndustriesSoil	N	Subset for alpha = 0.05	
		1	2
Q. soil	3	0.0700	
R. soil	3		0.1053
H. soil	3		0.1100
A. soil	3		0.1120
Control H.	3		0.1140
Control Q.	3		0.1140
Control R.	3		0.1140
Control A.	3		0.1140
Control B.	3		0.1140
B. soil	3		0.1160
Sig.		1.000	0.101

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

As, mg/kg

Duncan[a]

Chemical Soil Analysis of Industries	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
Control H.	3	0.0020					
Control Q.	3	0.0020					
Control A.	3	0.0020					
Control B.	3	0.0020					
B. soil	3	0.0040					
Q. soil	3		0.0190				
A. soil	3			0.0445			
Control R	3				0.1850		
R. soil	3					0.1950	
H. soil	3						0.2800
Sig.		0.533	1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Cr, mg/kg

Duncan[a]

Chemical Soil Analysis of Industries	N	Subset for alpha = 0.05				
		1	2	3	4	5
A. soil	3	0.0112				
Control H.	3	0.0187				
Q. soil	3		0.0770			
B. soil	3		0.0920			
R. soil	3			0.1200		
H. soil	3				0.1530	
Control Q.	3					0.1850
Control A.	3					0.1850
Control B.	3					0.1850
Control R.	3					0.1900
Sig.		0.347	0.067	1.000	1.000	0.562

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Statistical analysis

TBC, TPHB, TFC, TPH by Microbiological Analysis of Industries Soil

/STATISTICS DESCRIPTIVES HOMOGENEITY

/MISSING ANALYSIS

/POSTHOC=DUNCAN ALPHA(0.05).

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
TBC, CFU/g	H. soil	3	6200000	100000	57735.02692	5951586.229	6448413.771	6.10E+06	6.30E+06
	Control H	3	37000	45902.06967	26501.57228	-77027.0623	151027.0623	10000	90000
	Q. soil	3	1300000	100000	57735.02692	1051586.229	1548413.771	1.20E+06	1.40E+06
	Control Q	3	10000	3000	1732.05081	2547.5869	17452.4131	7000	13000
	R. soil	3	1200000	100000	57735.02692	951586.2288	1448413.771	1.10E+06	1.30E+06
	Control R	3	10000	3605.55128	2081.666	1043.3141	18956.6859	6000	13000
	A. soil	3	260000	10000	5773.50269	235158.6229	284841.3771	250000	270000
	Control A	3	9566.6667	3669.24152	2118.43758	451.7654	18681.5679	5700	13000
	B. soil	3	4800000	100000	57735.02692	4551586.229	5048413.771	4.70E+06	4.90E+06
	Control B	3	10000	2000	1154.70054	5031.7246	14968.2754	8000	12000
	Total	30	1383656.667	2171027.1	396373.5051	572981.8246	2194331.509	5700	6.30E+06
THUB, CFU/g	H. soil	3	2400	200	115.47005	1903.1725	2896.8275	2200	2600
	Control H	3	0	0	0	0	0	0	0
	Q. soil	3	0	0	0	0	0	0	0
	Control Q	3	0	0	0	0	0	0	0
	R. soil	3	10000	5000	2886.75135	-2420.6886	22420.6886	5000	15000
	Control R	3	0	0	0	0	0	0	0
	A. soil	3	0	0	0	0	0	0	0
	Control A	3	0	0	0	0	0	0	0
	B. soil	3	2000	1000	577.35027	-484.1377	4484.1377	1000	3000
	Control B	3	0	0	0	0	0	0	0
	Total	30	1440	3317.41486	605.67432	201.2569	2678.7431	0	15000

TFC, CFU/g	H. soil	3	5000	200	115.47005	4503.1725	5496.8275	4800	5200
	Control H	3	0	0	0	0	0	0	0
	Q. soil	3	0	0	0	0	0	0	0
	Control Q	3	0	0	0	0	0	0	0
	R. soil	3	2600	200	115.47005	2103.1725	3096.8275	2400	2800
	Control R	3	0	0	0	0	0	0	0
	A. soil	3	0	0	0	0	0	0	0
	Control A	3	0	0	0	0	0	0	0
	B. soil	3	3000	1000	577.35027	515.8623	5484.1377	2000	4000
	Control B	3	0	0	0	0	0	0	0
	Total	30	1060	1768.81024	322.93909	399.5154	1720.4846	0	5200
THU Fungi, CFU/g	H. soil	3	18000	2000	1154.70054	13031.7246	22968.2754	16000	20000
	Control H	3	6000	3000	1732.05081	-1452.4131	13452.4131	3000	9000
	Q. soil	3	25000	1000	577.35027	22515.8623	27484.1377	24000	26000
	Control Q	3	6000	264.57513	152.75252	5342.7589	6657.2411	5700	6200
	R. soil	3	65000	3000	1732.05081	57547.5869	72452.4131	62000	68000
	Control R	3	6000	264.57513	152.75252	5342.7589	6657.2411	5700	6200
	A. soil	3	1000	0	0	1000	1000	1000	1000
	Control A	3	6000	300	173.20508	5254.7587	6745.2413	5700	6300
	B. soil	3	18200	200	115.47005	17703.1725	18696.8275	18000	18400
	Control B	3	4320	3262.39176	1883.54276	-3784.2304	12424.2304	560	6400
	Total	30	15552	18400.33028	3359.42532	8681.2038	22422.7962	560	68000

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
TBC, CFU/g	2.210	9	20	0.067
THUB, CFU/g	3.788	9	20	0.006
TFC, CFU/g	3.638	9	20	0.008
THUFungi, CFU/g	3.019	9	20	0.019

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
TBC, CFU/g	Between Groups	1.36603E+14	9	1.51781E+13	3592.751	0
	Within Groups	84492926667	20	4224646333		
	Total	1.36687E+14	29			
THUB, CFU/g	Between Groups	267072000	9	29674666.67	11.396	0
	Within Groups	52080000	20	2604000		
	Total	319152000	29			
TFC, CFU/g	Between Groups	88572000	9	9841333.333	91.123	0
	Within Groups	2160000	20	108000		
	Total	90732000	29			
THU Fungi, CFU/g	Between Groups	9750766080	9	1083418453	319.468	0
	Within Groups	67826400	20	3391320		
	Total	9818592480	29			

Post Hoc Tests

Homogeneous Subsets

TBC, CFU/g

Duncan a

N	Subset for alpha = 0.05				
	1	2	3	4	5
3	9566.6667				
3	10000				
3	10000				
3	10000				
3	37000				
3		260000			
3			1200000		
3			1300000		
3				4800000	
3					6200000
	0.648	1	0.074	1	1

Means for groups in homogeneous subsets are displayed.

a Uses Harmonic Mean Sample Size = 3.000.

THUB, CFU/g

Duncan a

Microbiological Soil Analysis of Industries	N	Subset for alpha = 0.05	
		1	2
Control H	3	0	
Q. soil	3	0	
Control Q	3	0	
Control R	3	0	
A. soil	3	0	
Control A	3	0	
Control B	3	0	
B. soil	3	2000	
H. soil	3	2400	
R. soil	3		10000
Sig.		0.129	1

Means for groups in homogeneous subsets are displayed.

a Uses Harmonic Mean Sample Size = 3.000.

TFC, CFU/g

Duncan[a]

Microbiological Soil Analysis of Industries	N	Subset for alpha = 0.05		
		1	2	3
Control H	3	0.0000		
Q. soil	3	0.0000		
Control Q	3	0.0000		
Control R	3	0.0000		
A. soil	3	0.0000		
Control A	3	0.0000		
Control B	3	0.0000		
R. soil	3		2600.0000	
B. soil	3		3000.0000	
H. soil	3			5000.0000
Sig.		1.000	0.152	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

THU Fungi, CFU/g

Duncan[a]

Microbiological Analysis of Industries Soil	N	Subset for alpha = 0.05				
		1	2	3	4	5
A. soil	3	1000.0000				
Control B	3		4320.0000			
Control H	3		6000.0000			
Control Q	3		6000.0000			
Control R	3		6000.0000			
Control A	3		6000.0000			
H. soil	3			18000.0000		
B. soil	3			18200.0000		
Q. soil	3				25000.0000	
R. soil	3					65000.0000
Sig.		1.000	0.328	0.896	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Statistical analysis

Heavy metal analysis of *M. esculenta.*

ONEWAY Lead, Cadmium, Mercury, Arsenic, Chromium by Heavy metal Analysis of *M.esculenta*
STATISTICS DESCRIPTIVES HOMOGENEITY
/MISSING ANALYSIS
/POSTHOC=DUNCAN ALPHA(0.05).

Oneway

Descriptives

						95% Confidence			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Lead (mg/kg)	H. ME	3	0.0400	0.01000	0.00577	0.0152	0.0648	0.03	0.05
	Control H.	3	0.0200	0.01000	0.00577	-0.0048	0.0448	0.01	0.03
	Q. ME	3	0.0900	0.01732	0.01000	0.0470	0.1330	0.07	0.10
	Control Q.	3	0.0090	0.00100	0.00058	0.0065	0.0115	0.01	0.01
	R. ME	3	0.0570	0.00200	0.00115	0.0520	0.0620	0.06	0.06
	Control R.	3	0.0250	0.00200	0.00115	0.0200	0.0300	0.02	0.03
	A. ME	3	0.0133	0.00115	0.00067	0.0105	0.0162	0.01	0.01
	Control A	3	0.0070	0.00300	0.00173	-0.0005	0.0145	0.00	0.01
	B. ME	3	0.0080	0.00200	0.00115	0.0030	0.0130	0.01	0.01
	Control B	3	0.0030	0.00265	0.00153	-0.0036	0.0096	0.00	0.01
	Total	30	0.0272	0.02746	0.00501	0.0170	0.0375	0.00	0.10
Cadmium (mg/kg)	H. ME	3	0.0050	0.00100	0.00058	0.0025	0.0075	0.00	0.01
	Control H.	3	0.0050	0.00100	0.00058	0.0025	0.0075	0.00	0.01
	Q. ME	3	0.0100	0.00000	0.00000	0.0100	0.0100	0.01	0.01
	Control Q.	3	0.0050	0.00400	0.00231	-0.0049	0.0149	0.00	0.01
	R. ME	3	0.0040	0.00100	0.00058	0.0015	0.0065	0.00	0.01
	Control R.	3	0.0050	0.00300	0.00173	-0.0025	0.0125	0.00	0.01
	A. ME	3	0.0190	0.00800	0.00462	-0.0009	0.0389	0.01	0.03
	Control A.	3	0.0050	0.00400	0.00231	-0.0049	0.0149	0.00	0.01
	B. ME	3	0.0060	0.00200	0.00115	0.0010	0.0110	0.00	0.01
	Control B.	3	0.0050	0.00265	0.00153	-0.0016	0.0116	0.00	0.01
	Total	30	0.0069	0.00525	0.00096	0.0049	0.0089	0.00	0.03

Mercury (mg/kg)	H. ME	3	0.0220	0.00100	0.00058	0.0195	0.0245	0.02	0.02
	Control H.	3	0.0110	0.00100	0.00058	0.0085	0.0135	0.01	0.01
	Q. ME	3	0.0780	0.03118	0.01800	0.0006	0.1554	0.06	0.11
	Control Q	3	0.0110	0.00200	0.00115	0.0060	0.0160	0.01	0.01
	R. ME	3	0.0210	0.00100	0.00058	0.0185	0.0235	0.02	0.02
	Control R	3	0.0110	0.00400	0.00231	0.0011	0.0209	0.01	0.02
	A. ME	3	0.0310	0.00300	0.00173	0.0235	0.0385	0.03	0.03
	Control A	3	0.0120	0.00600	0.00346	-0.0029	0.0269	0.01	0.02
	B. ME	3	0.0120	0.00458	0.00265	0.0006	0.0234	0.01	0.02
	Control B	3	0.0110	0.00954	0.00551	-0.0127	0.0347	0.00	0.02
	Total	30	0.0220	0.02198	0.00401	0.0138	0.0302	0.00	0.11
Arsenic (mg/kg)	H. ME	3	0.0020	0.00173	0.00100	-0.0023	0.0063	0.00	0.00
	Control H	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Q. ME	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Control Q	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	R. ME	3	0.0010	0.00100	0.00058	-0.0015	0.0035	0.00	0.00
	Control R	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	A. ME	3	0.0060	0.00100	0.00058	0.0035	0.0085	0.01	0.01
	Control A	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	B. ME	3	0.0010	0.00000	0.00000	0.0010	0.0010	0.00	0.00
	Control B	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	30	0.0010	0.00191	0.00035	0.0003	0.0017	0.00	0.01
Chromium (mg/kg)	H. ME	3	0.0010	0.00000	0.00000	0.0010	0.0010	0.00	0.00
	Control H	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Q. ME	3	0.0200	0.01000	0.00577	-0.0048	0.0448	0.01	0.03
	Control Q	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	R. ME	3	0.0020	0.00200	0.00115	-0.0030	0.0070	0.00	0.00
	Control R	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	A. ME	3	0.0130	0.00200	0.00115	0.0080	0.0180	0.01	0.02
	Control A	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	B. ME	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Control B	3	0.0000	0.00000	0.00000	0.0000	0.0000	0.00	0.00
	Total	30	0.0036	0.00731	0.00133	0.0009	0.0063	0.00	0.03

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Lead (mg/kg)	4.610	9	20	0.002
Cadmium (mg/kg)	1.859	9	20	0.119
Mercury (mg/kg)	9.418	9	20	0.000
Arsenic (mg/kg)	6.519	9	20	0.000
Chromium (mg/kg)	3.638	9	20	0.008

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Lead (mg/kg)	Between Groups	0.021	9	0.002	43.609	0.000
	Within Groups	0.001	20	0.000		
	Total	0.022	29			
Cadmium (mg/kg)	Between Groups	0.001	9	0.000	5.235	0.001
	Within Groups	0.000	20	0.000		
	Total	0.001	29			
Mercury (mg/kg)	Between Groups	0.012	9	0.001	11.291	0.000
	Within Groups	0.002	20	0.000		
	Total	0.014	29			
Arsenic (mg/kg)	Between Groups	0.000	9	0.000	21.333	0.000
	Within Groups	0.000	20	0.000		
	Total	0.000	29			
Chromium (mg/kg)	Between Groups	0.001	9	0.000	13.716	0.000
	Within Groups	0.000	20	0.000		
	Total	0.002	29			

Post Hoc Tests
Homogeneous Subsets

Lead (mg/kg)

Duncan[a]

Heavy metal Analysis of *M.esculenta*	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
Control B.	3	0.0030					
Control A.	3	0.0070	0.0070				
B. ME	3	0.0080	0.0080				
Control Q.	3	0.0090	0.0090				
A. ME	3	0.0133	0.0133	0.0133			
Control H.	3		0.0200	0.0200			
Control R.	3			0.0250			
H. ME	3				0.0400		
R. ME	3					0.0570	
Q. ME	3						0.0900
Sig.		0.133	0.062	0.077	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Cadmium (mg/kg)

Duncan[a]

Heavy metal Analysis of *M.esculenta*	N	Subset for alpha = 0.05	
		1	2
R. ME	3	0.0040	
H. ME	3	0.0050	
Control H.	3	0.0050	
Control Q.	3	0.0050	
Control R.	3	0.0050	
Control A.	3	0.0050	
Control B.	3	0.0050	
B. ME	3	0.0060	
Q. ME	3	0.0100	
A. ME	3		0.0190
Sig.		0.079	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Mercury (mg/kg)

Duncan[a]

Heavy metal Analysisof *M.esculenta*	N	Subset for alpha = 0.05	
		1	2
Control H.	3	0.0110	
Control Q.	3	0.0110	
Control R.	3	0.0110	
Control B.	3	0.0110	
B. ME	3	0.0120	
Control A.	3	0.0120	
R. ME	3	0.0210	
H. ME	3	0.0220	
A. ME	3	0.0310	
Q. ME	3		0.0780
Sig.		0.061	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Arsenic (mg/kg)

Duncan[a]

Heavymetal Analysis of *M.esculenta*	N	Subset for alpha = 0.05		
		1	2	3
Control H.	3	0.0000		
Q. ME	3	0.0000		
Control Q.	3	0.0000		
Control R.	3	0.0000		
Control A.	3	0.0000		
Control B.	3	0.0000		
R. ME	3	0.0010	0.0010	
B. ME	3	0.0010	0.0010	
H. ME	3		0.0020	
A. ME	3			0.0060
Sig.		0.146	0.116	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Chromium (mg/kg)

Duncan[a]

Heavy metal Analysis of *M.esculenta*	N	Subset for alpha = 0.05 1	2	3
Control H.	3	0.0000		
Control Q.	3	0.0000		
Control R.	3	0.0000		
Control A.	3	0.0000		
B. ME	3	0.0000		
Control B	3	0.0000		
H. ME	3	0.0010		
R. ME	3	0.0020		
A. ME	3		0.0130	
Q. ME	3			0.0200
Sig.		0.521	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Statistical analysis

Heavy metal analysis of *C. papaya.*

ONEWAY Lead Cadmium Mercury Arsenic Chromium by Heavy metal Analysis of *C. papaya.*

STATISTICS DESCRIPTIVES HOMOGENEITY

/MISSING ANALYSIS

/POSTHOC=DUNCAN ALPHA(0.05).

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Lower Bound	95% Confidence Upper Bound	Minimum	Maximum
Lead (mg/kg)	H. CP	3	0.0320	0.00200	0.00115	0.0270	0.0370	0.03	0.03
	Control H	3	0.0080	0.00200	0.00115	0.0030	0.0130	0.01	0.01
	Q. CP	3	0.4430	0.01652	0.00954	0.4020	0.4840	0.43	0.46
	Control Q	3	0.0380	0.00200	0.00115	0.0330	0.0430	0.04	0.04
	R. CP	3	0.0320	0.01000	0.00577	0.0072	0.0568	0.02	0.04
	Control R	3	0.0160	0.00300	0.00173	0.0085	0.0235	0.01	0.02
	A. CP	3	0.0610	0.00100	0.00058	0.0585	0.0635	0.06	0.06
	Control A	3	0.0070	0.00100	0.00058	0.0045	0.0095	0.01	0.01
	B. CP	3	0.0420	0.00173	0.00100	0.0377	0.0463	0.04	0.04
	Control B	3	0.0080	0.00300	0.00173	0.0005	0.0155	0.01	0.01
	Total	30	0.0687	0.12814	0.02340	0.0209	0.1165	0.01	0.46
Cadmium (mg/kg)	H. CP	3	0.0090	0.00265	0.00153	0.0024	0.0156	0.01	0.01
	Control H	3	0.0110	0.00100	0.00058	0.0085	0.0135	0.01	0.01
	Q. CP	3	0.0210	0.00346	0.00200	0.0124	0.0296	0.02	0.03
	Control Q	3	0.0110	0.00100	0.00058	0.0085	0.0135	0.01	0.01
	R. CP	3	0.0090	0.00173	0.00100	0.0047	0.0133	0.01	0.01
	Control R	3	0.0110	0.00100	0.00058	0.0085	0.0135	0.01	0.01
	A. CP	3	0.0090	0.00100	0.00058	0.0065	0.0115	0.01	0.01
	Control A	3	0.0110	0.00100	0.00058	0.0085	0.0135	0.01	0.01
	B. CP	3	0.0090	0.00200	0.00115	0.0040	0.0140	0.01	0.01
	Control B	3	0.0110	0.00100	0.00058	0.0085	0.0135	0.01	0.01
	Total	30	0.0112	0.00376	0.00069	0.0098	0.0126	0.01	0.03

Mercury (mg/kg)	H. CP	3	0.0080	0.00361	0.00208	-0.0010	0.0170	0.00	0.01
	Control H	3	0.0140	0.00300	0.00173	0.0065	0.0215	0.01	0.02
	Q. CP	3	0.0210	0.00265	0.00153	0.0144	0.0276	0.02	0.02
	Control Q	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	R. CP	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	Control R	3	0.0140	0.00100	0.00058	0.0115	0.0165	0.01	0.02
	A. CP	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	Control A	3	0.0110	0.00100	0.00058	0.0085	0.0135	0.01	0.01
	B. CP	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	Control B	3	0.0070	0.00100	0.00058	0.0045	0.0095	0.01	0.01
	Total	30	0.0115	0.00669	0.00122	0.0090	0.0140	0.00	0.02
Arsenic (mg/kg)	H. CP	3	0.0020	0.00100	0.00058	-0.0005	0.0045	0.00	0.00
	Control H	3	0.0010	0.00100	0.00058	-0.0015	0.0035	0.00	0.00
	Q. CP	3	0.0020	0.00000	0.00000	0.0020	0.0020	0.00	0.00
	Control Q	3	0.0010	0.00100	0.00058	-0.0015	0.0035	0.00	0.00
	R. CP	3	0.0030	0.00173	0.00100	-0.0013	0.0073	0.00	0.00
	Control R	3	0.0010	0.00100	0.00058	-0.0015	0.0035	0.00	0.00
	A. CP	3	0.0030	0.00200	0.00115	-0.0020	0.0080	0.00	0.01
	Control A	3	0.0010	0.00100	0.00058	-0.0015	0.0035	0.00	0.00
	B. CP	3	0.0010	0.00100	0.00058	-0.0015	0.0035	0.00	0.00
	Control B	3	0.0010	0.00100	0.00058	-0.0015	0.0035	0.00	0.00
	Total	30	0.0016	0.00128	0.00023	0.0011	0.0021	0.00	0.01
Chromium (mg/kg)	H. CP	3	0.0010	0.00000	0.00000	0.0010	0.0010	0.00	0.00
	Control H	3	0.0020	0.00100	0.00058	-0.0005	0.0045	0.00	0.00
	Q. CP	3	0.0180	0.00700	0.00404	0.0006	0.0354	0.01	0.02
	Control Q	3	0.0120	0.00100	0.00058	0.0095	0.0145	0.01	0.01
	R. CP	3	0.0100	0.00500	0.00289	-0.0024	0.0224	0.01	0.02
	Control R	3	0.0120	0.00100	0.00058	0.0095	0.0145	0.01	0.01
	A. CP	3	0.0100	0.01000	0.00577	-0.0148	0.0348	0.00	0.02
	Control A	3	0.0120	0.00100	0.00058	0.0095	0.0145	0.01	0.01
	B. CP	3	0.0090	0.00361	0.00208	0.0000	0.0180	0.01	0.01
	Control B	3	0.0020	0.00100	0.00058	-0.0005	0.0045	0.00	0.00
	Total	30	0.0088	0.00643	0.00117	0.0064	0.0112	0.00	0.02

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Lead (mg/kg)	2.853	9	20	0.024
Cadmium (mg/kg)	2.494	9	20	0.043
Mercury (mg/kg)	1.644	9	20	0.170
Arsenic (mg/kg)	1.074	9	20	0.422
Chromium (mg/kg)	3.066	9	20	0.018

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Lead (mg/kg)	Between Groups	0.475	9	0.053	1294.625	0.000
	Within Groups	0.001	20	0.000		
	Total	0.476	29			
Cadmium (mg/kg)	Between Groups	0.000	9	0.000	12.042	0.000
	Within Groups	0.000	20	0.000		
	Total	0.000	29			
Mercury (mg/kg)	Between Groups	0.000	9	0.000	1.115	0.397
	Within Groups	0.001	20	0.000		
	Total	0.001	29			
Arsenic (mg/kg)	Between Groups	0.000	9	0.000	1.524	0.207
	Within Groups	0.000	20	0.000		
	Total	0.000	29			
Chromium (mg/kg)	Between Groups	0.001	9	0.000	4.715	0.002
	Within Groups	0.000	20	0.000		
	Total	0.001	29			

Post Hoc Tests

Homogeneous Subsets

Lead (mg/kg)

Duncan[a]

Heavy metal Analysis of *C. papaya.*	N	Subset for alpha = 0.05			
		1	2	3	4
Control A.	3	0.0070			
Control H.	3	0.0080			
Control B.	3	0.0080			
Control R.	3	0.0160			
H. CP	3		0.0320		
R. CP	3		0.0320		
Control Q.	3		0.0380		
B. CP	3		0.0420		
A. CP	3			0.0610	
Q. CP	3				0.4430
Sig.		0.128	0.092	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Cadmium (mg/kg)

Duncan[a]

Heavy metal Analysis of *C. papaya*.	N	Subset for alpha = 0.05	
		1	2
R. CP	3	0.0090	
B. CP	3	0.0090	
H. CP	3	0.0090	
A. CP	3	0.0090	
Control H.	3	0.0110	
Control Q.	3	0.0110	
Control R.	3	0.0110	
Control A.	3	0.0110	
Control B.	3	0.0110	
Q. CP	3		0.0210
Sig.		0.247	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Mercury (mg/kg)

Duncan[a]

Heavy metal Analysis of *C. papaya.*	N	Subset for alpha = 0.05	
		1	2
Control B.	3	0.0070	
H. CP	3	0.0080	
Control Q.	3	0.0100	0.0100
R. CP	3	0.0100	0.0100
A. CP	3	0.0100	0.0100
B. CP	3	0.0100	0.0100
Control A.	3	0.0110	0.0110
Control R.	3	0.0140	0.0140
Control H.	3	0.0140	0.0140
Q. CP	3		0.0210
Sig.		0.269	0.088

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Arsenic (mg/kg)

Duncan[a]

Heavy metal Analysis of *C. papaya.*	N	Subset for alpha = 0.05
		1
Control H.	3	0.0010
Control Q.	3	0.0010
Control R.	3	0.0010
Control A.	3	0.0010
B. CP	3	0.0010
Control B	3	0.0010
H. CP	3	0.0020
Q. CP	3	0.0020
R. CP	3	0.0030
A. CP	3	0.0030
Sig.		0.088

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Chromium (mg/kg)

Duncan[a]

Heavy metal Analysis of *C.papaya*	N	Subset for alpha = 0.05 1	2	3	4
H. CP	3	0.0010			
Control H.	3	0.0020	0.0020		
Control B.	3	0.0020	0.0020		
B. CP	3	0.0090	0.0090	0.0090	
R. CP	3		0.0100	0.0100	0.0100
A. CP	3		0.0100	0.0100	0.0100
Control Q	3			0.0120	0.0120
Control R	3			0.0120	0.0120
Control A	3			0.0120	0.0120
Q. CP	3				0.0180
Sig.		0.052	0.056	0.466	0.060

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

ONEWAY Moisture Content, Ash Content, Crude Protein Content, Lipid Content, Fibre Content, Carbohydrate Content by Proximate Analysis of *M.esculenta*

/STATISTICS DESCRIPTIVES HOMOGENEITY

/MISSING ANALYSIS

/POSTHOC=DUNCAN ALPHA(0.05).

Descriptives

						95% Confidence			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Moisture content (%)	H. ME	3	59.7000	2.64575	1.52753	53.1276	66.2724	57.70	62.70
	Control H	3	22.8500	0.05000	0.02887	22.7258	22.9742	22.80	22.90
	Q. ME	3	66.1000	0.10000	0.05774	65.8516	66.3484	66.00	66.20
	Control Q	3	32.8500	0.03000	0.01732	32.7755	32.9245	32.82	32.88
	R. ME	3	70.6400	0.43405	0.25060	69.5618	71.7182	70.36	71.14
	Control R	3	62.8500	0.04000	0.02309	62.7506	62.9494	62.81	62.89
	A. ME	3	59.9900	5.04027	2.91000	47.4693	72.5107	54.98	65.06
	Control A	3	42.8500	0.05000	0.02887	42.7258	42.9742	42.80	42.90
	B. ME	3	62.3000	0.20000	0.11547	61.8032	62.7968	62.10	62.50
	Control B	3	66.8500	0.01000	0.00577	66.8252	66.8748	66.84	66.86
	Total	30	54.6980	15.63440	2.85444	48.8600	60.5360	22.80	71.14
Ash Content (%)	H. ME	3	9.0400	1.00504	0.58026	6.5433	11.5367	8.03	10.04
	Control H	3	2.8000	0.10000	0.05774	2.5516	3.0484	2.70	2.90
	Q. ME	3	3.1900	0.01000	0.00577	3.1652	3.2148	3.18	3.20
	Control Q	3	0.2000	0.10000	0.05774	-0.0484	0.4484	0.10	0.30
	R. ME	3	8.0000	3.60555	2.08167	-0.9567	16.9567	5.00	12.00
	Control R	3	2.8000	0.20000	0.11547	2.3032	3.2968	2.60	3.00
	A. ME	3	6.8800	1.65227	0.95394	2.7755	10.9845	4.98	7.98
	Control A	3	2.1000	0.10000	0.05774	1.8516	2.3484	2.00	2.20
	B. ME	3	3.8100	0.01000	0.00577	3.7852	3.8348	3.80	3.82
	Control B	3	2.8000	0.10000	0.05774	2.5516	3.0484	2.70	2.90
	Total	30	4.1620	2.94272	0.53726	3.0632	5.2608	0.10	12.00

Crude Protein Content (%)	H. ME	3	10.0700	0.01000	0.00577	10.0452	10.0948	10.06	10.08
	Control H	3	6.4000	0.40000	0.23094	5.4063	7.3937	6.00	6.80
	Q. ME	3	14.0000	2.64575	1.52753	7.4276	20.5724	11.00	16.00
	Control Q	3	5.8000	0.10000	0.05774	5.5516	6.0484	5.70	5.90
	R. ME	3	8.6500	0.02646	0.01528	8.5843	8.7157	8.62	8.67
	Control R	3	6.2000	0.20000	0.11547	5.7032	6.6968	6.00	6.40
	A. ME	3	8.4500	0.99504	0.57449	5.9782	10.9218	7.46	9.45
	Control A	3	2.8000	0.10000	0.05774	2.5516	3.0484	2.70	2.90
	B. ME	3	7.8300	0.03000	0.01732	7.7555	7.9045	7.80	7.86
	Control B	3	2.4000	0.10000	0.05774	2.1516	2.6484	2.30	2.50
	Total	30	7.2600	3.37308	0.61584	6.0005	8.5195	2.30	16.00
Lipid Content (%)	H. ME	3	2.3300	0.01000	0.00577	2.3052	2.3548	2.32	2.34
	Control H	3	0.2000	0.10000	0.05774	-0.0484	0.4484	0.10	0.30
	Q. ME	3	0.4400	0.01732	0.01000	0.3970	0.4830	0.42	0.45
	Control Q	3	0.4100	0.01000	0.00577	0.3852	0.4348	0.40	0.42
	R. ME	3	2.6800	0.04000	0.02309	2.5806	2.7794	2.64	2.72
	Control R	3	4.2000	0.10000	0.05774	3.9516	4.4484	4.10	4.30
	A. ME	3	3.4300	0.02646	0.01528	3.3643	3.4957	3.41	3.46
	Control A	3	0.2100	0.01000	0.00577	0.1852	0.2348	0.20	0.22
	B. ME	3	3.2000	0.00000	0.00000	3.2000	3.2000	3.20	3.20
	Control B	3	3.2000	0.10000	0.05774	2.9516	3.4484	3.10	3.30
	Total	30	2.0300	1.50017	0.27389	1.4698	2.5902	0.10	4.30
Fibre Content (%)	H. CP	3	3.6100	0.04583	0.02646	3.4962	3.7238	3.56	3.65
	Control H	3	0.4100	0.01000	0.00577	0.3852	0.4348	0.40	0.42
	Q. ME	3	6.6500	1.00504	0.58026	4.1533	9.1467	5.65	7.66
	Control Q	3	6.4000	0.20000	0.11547	5.9032	6.8968	6.20	6.60
	R. ME	3	5.1300	0.02646	0.01528	5.0643	5.1957	5.11	5.16
	Control R	3	0.4100	0.01000	0.00577	0.3852	0.4348	0.40	0.42
	A. ME	3	0.3900	0.03000	0.01732	0.3155	0.4645	0.36	0.42
	Control A	3	6.4000	0.20000	0.11547	5.9032	6.8968	6.20	6.60
	B. ME	3	8.7700	0.02000	0.01155	8.7203	8.8197	8.75	8.79
	Control B	3	0.4100	0.01000	0.00577	0.3852	0.4348	0.40	0.42
	Total	30	3.8580	3.13405	0.57220	2.6877	5.0283	0.36	8.79
Carbohydrate Content (%)	H. ME	3	15.2500	1.74072	1.00500	10.9258	19.5742	13.24	16.26
	Control H	3	50.3400	0.01000	0.00577	50.3152	50.3648	50.33	50.35
	Q. ME	3	9.6200	0.04583	0.02646	9.5062	9.7338	9.57	9.66
	Control Q	3	5.3400	0.03000	0.01732	5.2655	5.4145	5.31	5.37
	R. ME	3	4.9000	0.85440	0.49329	2.7776	7.0224	4.10	5.80
	Control R	3	5.3400	0.01000	0.00577	5.3152	5.3648	5.33	5.35
	A. ME	3	20.8600	0.04000	0.02309	20.7606	20.9594	20.82	20.90
	Control A	3	30.3400	0.01000	0.00577	30.3152	30.3648	30.33	30.35
	B. ME	3	14.0900	0.01000	0.00577	14.0652	14.1148	14.08	14.10
	Control B	3	20.3400	0.02000	0.01155	20.2903	20.3897	20.32	20.36
	Total	30	17.6420	13.63921	2.49017	12.5490	22.7350	4.10	50.35

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Moisture content (%)	4.269	9	20	0.003
Ash Content (%)	7.394	9	20	0.000
Crude Protein Content (%)	8.210	9	20	0.000
Lipid Content (%)	2.141	9	20	0.075
Fibre Content (%)	3.555	9	20	0.009
Carbohydrate Content (%)	10.941	9	20	0.000

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture content (%)	Between Groups	7023.300	9	780.367	239.008	0.000
	Within Groups	65.301	20	3.265		
	Total	7088.601	29			
Ash Content (%)	Between Groups	217.487	9	24.165	14.367	0.000
	Within Groups	33.641	20	1.682		
	Total	251.128	29			
Crude Protein Content (%)	Between Groups	313.508	9	34.834	42.368	0.000
	Within Groups	16.444	20	0.822		
	Total	329.952	29			
Lipid Content (%)	Between Groups	65.199	9	7.244	2201.925	0.000
	Within Groups	0.066	20	0.003		
	Total	65.265	29			
Fibre Content (%)	Between Groups	282.657	9	31.406	286.947	0.000
	Within Groups	2.189	20	0.109		
	Total	284.846	29			
Carbohydrate Content (%)	Between Groups	5387.283	9	598.587	1589.661	0.000
	Within Groups	7.531	20	0.377		
	Total	5394.814	29			

Post Hoc Tests

Homogeneous Subsets

Moisture content (%)

Duncan[a]

Proximate Analysis of *M.esculenta*	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
Control H	3	22.8500					
Control Q	3		32.8500				
Control A	3			42.8500			
H. CP	3				59.7000		
A. ME	3				59.9900		
B. ME	3				62.3000		
Control R	3				62.8500		
Q. ME	3					66.1000	
Control B	3					66.8500	
R. ME	3						70.6400
Sig.		1.000	1.000	1.000	0.063	0.617	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Ash Content (%)

Duncan[a]

Proximate Analysis of *M.esculenta*	N	Subset for alpha = 0.05		
		1	2	3
Control Q	3	0.2000		
Control A	3	2.1000	2.1000	
Control H	3		2.8000	
Control R	3		2.8000	
Control B	3		2.8000	
Q. ME	3		3.1900	
B. ME	3		3.8100	
A. ME	3			6.8800
R. ME	3			8.0000
H. CP	3			9.0400
Sig.		0.088	0.167	0.066

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Crude Protein Content (%)

Duncana

Proximate Analysis of *M.esculenta*	N	Subset for alpha = 0.05 1	2	3	4	5	6
Control B	3	2.4000					
Control A	3	2.8000					
Control Q	3		5.8000				
Control R	3		6.2000				
Control H	3		6.4000	6.4000			
B. ME	3			7.8300	7.8300		
A. ME	3				8.4500	8.4500	
R. ME	3				8.6500	8.6500	
H. ME	3					10.0700	
Q. ME	3						14.0000
Sig.		0.595	0.453	0.068	0.308	0.050	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Lipid Content (%)

Duncan[a]

Proximate Analysis of *M.esculenta*	N	Subset for alpha = 0.05 1	2	3	4	5	6	7
Control H	3	0.2000						
Control A	3	0.2100						
Control Q	3		0.4100					
Q. ME	3		0.4400					
H. ME	3			2.3300				
R. ME	3				2.6800			
B. ME	3					3.2000		
Control B	3					3.2000		
A. ME	3						3.4300	
Control R	3							4.2000
Sig.		0.833	0.529	1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Fibre Content (%)

Duncan[a]

Proximate Analysis of *M.esculenta*	N	Subset for alpha = 0.05: 1	2	3	4	5
A. ME	3	0.3900				
Control H	3	0.4100				
Control R	3	0.4100				
Control B	3	0.4100				
H. CP	3		3.6100			
R. ME	3			5.1300		
Control Q	3				6.4000	
Control A	3				6.4000	
Q. ME	3				6.6500	
B. ME	3					8.7700
Sig.		0.947	1.000	1.000	0.392	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Carbohydrate Content (%)

Duncan[a]

Proximate Analysis of *M.esculenta*	N	Subset for alpha = 0.05: 1	2	3	4	5	6	7
R. ME	3	4.9000						
Control Q	3	5.3400						
Control R	3	5.3400						
Q. ME	3		9.6200					
B. ME	3			14.0900				
H. CP	3				15.2500			
Control B	3					20.3400		
A. ME	3					20.8600		
Control A	3						30.3400	
Control H	3							50.3400
Sig.		0.417	1.000	1.000	1.000	0.312	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Statistical analysis

ONEWAY Moisture Content, Ash Content, Crude Protein Content, Lipid Content, Fibre Content, Carbohydrate Content, by Proximate Analysis of *C.papaya*

/STATISTICS DESCRIPTIVES HOMOGENEITY

/MISSING ANALYSIS

/POSTHOC=DUNCAN ALPHA(0.05).

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Lower Bound	95% Confidence Upper Bound	Minimum	Maximum
Moisture content (%)	H. CP	3	74.8000	1.05357	0.60828	72.1828	77.4172	73.80	75.90
	Control H	3	14.5500	0.02000	0.01155	14.5003	14.5997	14.53	14.57
	Q. CP	3	74.9867	0.01155	0.00667	74.9580	75.0154	74.98	75.00
	Control Q	3	64.7500	0.01000	0.00577	64.7252	64.7748	64.74	64.76
	R. CP	3	77.4400	0.96390	0.55651	75.0455	79.8345	76.43	78.35
	Control R	3	74.5500	0.03000	0.01732	74.4755	74.6245	74.52	74.58
	A. CP	3	72.1600	0.98000	0.56580	69.7255	74.5945	71.18	73.14
	Control A	3	64.5500	0.04000	0.02309	64.4506	64.6494	64.51	64.59
	B. CP	3	75.2700	0.02000	0.01155	75.2203	75.3197	75.25	75.29
	Control B	3	70.5467	0.04509	0.02603	70.4347	70.6587	70.50	70.59
	Total	30	66.3603	18.07513	3.30005	59.6110	73.1097	14.53	78.35
Ash Content (%)	H. CP	3	5.9600	0.05568	0.03215	5.8217	6.0983	5.91	6.02
	Control H	3	4.0000	0.20000	0.11547	3.5032	4.4968	3.80	4.20
	Q. CP	3	8.0700	0.98000	0.56580	5.6355	10.5045	7.09	9.05
	Control Q	3	4.8000	0.10000	0.05774	4.5516	5.0484	4.70	4.90
	R. CP	3	5.5333	1.52753	0.88192	1.7388	9.3279	4.20	7.20
	Control R	3	4.0000	0.30000	0.17321	3.2548	4.7452	3.70	4.30
	A. CP	3	6.7333	1.24231	0.71725	3.6473	9.8194	5.30	7.50
	Control A	3	4.0000	1.00000	0.57735	1.5159	6.4841	3.00	5.00
	B. CP	3	7.6400	0.02000	0.01155	7.5903	7.6897	7.62	7.66
	Control B	3	4.0000	1.00000	0.57735	1.5159	6.4841	3.00	5.00
	Total	30	5.4737	1.67296	0.30544	4.8490	6.0984	3.00	9.05

Crude Protein Content (%)	H. CP	3	9.1000	0.90000	0.51962	6.8643	11.3357	8.20	10.00
	Control H	3	15.6000	0.10000	0.05774	15.3516	15.8484	15.50	15.70
	Q. CP	3	10.5900	0.25710	0.14844	9.9513	11.2287	10.30	10.79
	Control Q	3	4.0000	0.40000	0.23094	3.0063	4.9937	3.60	4.40
	R. CP	3	8.9000	2.15174	1.24231	3.5548	14.2452	6.80	11.10
	Control R	3	15.6000	0.10000	0.05774	15.3516	15.8484	15.50	15.70
	A. CP	3	11.5200	0.90504	0.52253	9.2718	13.7682	10.61	12.42
	Control A	3	15.6000	0.10000	0.05774	15.3516	15.8484	15.50	15.70
	B. CP	3	8.7400	0.02000	0.01155	8.6903	8.7897	8.72	8.76
	Control B	3	15.6000	0.10000	0.05774	15.3516	15.8484	15.50	15.70
	Total	30	11.5250	3.92341	0.71631	10.0600	12.9900	3.60	15.70
Lipid Content (%)	H. CP	3	2.8700	0.02646	0.01528	2.8043	2.9357	2.84	2.89
	Control H	3	4.8000	0.10000	0.05774	4.5516	5.0484	4.70	4.90
	Q. CP	3	4.3700	0.03606	0.02082	4.2804	4.4596	4.34	4.41
	Control Q	3	0.0200	0.01000	0.00577	-0.0048	0.0448	0.01	0.03
	R. CP	3	4.1200	1.00000	0.57735	409.5159	414.4841	411.00	413.00
	Control R	3	8.4800	0.20000	0.11547	84.3032	85.2968	84.60	85.00
	A. CP	3	3.9700	0.99000	0.57158	1.5107	6.4293	2.98	4.96
	Control A	3	2.8000	0.10000	0.05774	2.5516	3.0484	2.70	2.90
	B. CP	3	0.8400	0.02000	0.01155	0.7903	0.8897	0.82	0.86
	Control B	3	0.4800	0.01000	0.00577	0.4552	0.5048	0.47	0.49
	Total	30	51.6950	124.68757	22.76473	5.1359	98.2541	0.01	413.00
Fibre Content (%)	H. CP	3	4.6300	1.07531	0.62083	1.9588	7.3012	3.54	5.69
	Control H	3	0.0250	0.01500	0.00866	-0.0123	0.0623	0.01	0.04
	Q. CP	3	0.7100	0.05000	0.02887	0.5858	0.8342	0.66	0.76
	Control Q	3	12.6000	0.10000	0.05774	12.3516	12.8484	12.50	12.70
	R. CP	3	3.7700	0.03000	0.01732	3.6955	3.8445	3.74	3.80
	Control R	3	0.0200	0.01000	0.00577	-0.0048	0.0448	0.01	0.03
	A. CP	3	0.4400	0.04000	0.02309	0.3406	0.5394	0.40	0.48
	Control A	3	0.0200	0.01000	0.00577	-0.0048	0.0448	0.01	0.03
	B. CP	3	1.8600	0.02000	0.01155	1.8103	1.9097	1.84	1.88
	Control B	3	0.0200	0.01000	0.00577	-0.0048	0.0448	0.01	0.03
	Total	30	2.4095	3.82316	0.69801	0.9819	3.8371	0.01	12.70
Carbohydrate Content (%)	H. CP	3	2.6400	0.08000	0.04619	2.4413	2.8387	2.56	2.72
	Control H	3	16.0300	0.01000	0.00577	16.0052	16.0548	16.02	16.04
	Q. CP	3	1.2700	0.04583	0.02646	1.1562	1.3838	1.23	1.32
	Control Q	3	1.0300	0.01000	0.00577	1.0052	1.0548	1.02	1.04
	R. CP	3	1.5700	0.01000	0.00577	1.5452	1.5948	1.56	1.58
	Control R	3	1.0300	0.01000	0.00577	1.0052	1.0548	1.02	1.04
	A. CP	3	5.5100	0.06557	0.03786	5.3471	5.6729	5.45	5.58
	Control A	3	6.0300	0.02000	0.01155	5.9803	6.0797	6.01	6.05
	B. CP	3	5.6333	0.03215	0.01856	5.5535	5.7132	5.61	5.67
	Control B	3	10.0300	0.01000	0.00577	10.0052	10.0548	10.02	10.04
	Total	30	5.0773	4.67646	0.85380	3.3311	6.8236	1.02	16.04

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Moisture content (%)	3.604	9	20	0.008
Ash Content (%)	2.952	9	20	0.021
Crude Protein Content (%)	3.041	9	20	0.018
Lipid Content (%)	3.087	9	20	0.017
Fibre Content (%)	4.069	9	20	0.004
Carbohydrate Content (%)	2.437	9	20	0.047

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture content (%)	Between Groups	9468.588	9	1052.065	3500.972	0
	Within Groups	6.01	20	0.301		
	Total	9474.598	29			
Ash Content (%)	Between Groups	67.204	9	7.467	10.697	0
	Within Groups	13.961	20	0.698		
	Total	81.165	29			
Crude Protein Content (%)	Between Groups	433.35	9	48.15	73.786	0
	Within Groups	13.051	20	0.653		
	Total	446.401	29			
Lipid Content (%)	Between Groups	450.859	9	50.095	245241.1	0
	Within Groups	4.085	20	0.204		
	Total	450862.748	29			
Fibre Content (%)	Between Groups	421.536	9	46.837	399.559	0
	Within Groups	2.344	20	0.117		
	Total	423.881	29			
Carbohydrate Content (%)	Between Groups	634.18	9	70.464	47826.54	0
	Within Groups	0.029	20	0.001		
	Total	634.209	29			

Post Hoc Tests

Homogeneous Subsets

Moisture content (%)

Duncan[a]

Proximate Analysis of *C.papaya*	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
Control H	3	14.5500					
Control A	3		64.5500				
Control Q	3		64.7500				
Control B	3			70.5467			
A. CP	3				72.1600		
Control R	3					74.5500	
H. CP	3					74.8000	
Q. CP	3					74.9867	
B. CP	3					75.2700	
R. CP	3						77.4400
Sig.		1.000	0.660	1.000	1.000	0.155	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Ash Content (%)

Duncan[a]

Proximate Analysis of *C.papaya*	N	Subset for alpha = 0.05			
		1	2	3	4
Control H	3	4.0000			
Control R	3	4.0000			
Control A	3	4.0000			
Control B	3	4.0000			
Control Q	3	4.8000	4.8000		
R. CP	3	5.5333	5.5333	5.5333	
H. CP	3		5.9600	5.9600	
A. CP	3			6.7333	6.7333
B. CP	3				7.6400
Q. CP	3				8.0700
Sig.		0.059	0.122	0.110	0.077

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Crude Protein Content (%)

Duncan[a]

Proximate Analysis of *C.papaya*	N	Subset for alpha = 0.05			
		1	2	3	4
Control Q	3	4.0000			
B. CP	3		8.7400		
R. CP	3		8.9000		
H. CP	3		9.1000		
Q. CP	3			10.5900	
A. CP	3			11.5200	
Control H	3				15.6000
Control R	3				15.6000
Control A	3				15.6000
Control B	3				15.6000
Sig.		1.000	0.612	0.174	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Lipid Content (%)

Duncan[a]

Proximate Analysis of *C.papaya*	N	Subset for alpha = 0.05						
		1	2	3	4	5	6	7
Control Q	3	0.0200						
Control B	3	0.4800	0.4800					
B. CP	3		0.8400					
Control A	3			2.8000				
H. CP	3			2.8700				
A. CP	3				3.9700			
Q. CP	3				4.3700	4.3700		
Control H	3					4.8000		
Control R	3						84.8000	
R. CP	3				4.1200			
Sig.		0.227	0.341	0.851	0.291	0.258	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Fibre Content (%)

Duncan[a]

Proximate Analysis of *C.papaya*	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
Control R	3	0.0200					
Control A	3	0.0200					
Control B	3	0.0200					
Control H	3	0.0250					
A. CP	3	0.4400	0.4400				
Q. CP	3		0.7100				
B. CP	3			1.8600			
R. CP	3				3.7700		
H. CP	3					4.6300	
Control Q	3						12.6000
Sig.		0.192	0.346	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Fibre Content (%)

Duncan[a]

Proximate Analysis of *C.papaya*	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
Control R	3	0.0200					
Control A	3	0.0200					
Control B	3	0.0200					
Control H	3	0.0250					
A. CP	3	0.4400	0.4400				
Q. CP	3		0.7100				
B. CP	3			1.8600			
R. CP	3				3.7700		
H. CP	3					4.6300	
Control Q	3						12.6000
Sig.		0.192	0.346	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Carbohydrate Content (%)

Duncan[a]

Proximate Analysis of *C.papaya*	N	Subset for alpha = 0.05								
		1	2	3	4	5	6	7	8	9
Control Q	3	1.0300								
Control R	3	1.0300								
Q. CP	3		1.2700							
R. CP	3			1.5700						
H. CP	3				2.6400					
A. CP	3					5.5100				
B. CP	3						5.6333			
Control A	3							6.0300		
Control B	3								10.0300	
Control H	3									16.0300
Sig.		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.