International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
DOI: 10.22192/ijarbs **Coden: IJARQG (USA)** **Volume 7, Issue 7 -2020**

Review Article

DOI: http://dx.doi.org/10.22192/ijarbs.2020.07.07.014

Environmental impact of palm oil mill effluent and its management through biotechnological approaches

[1]Okereke, J. N. and [1]Ginikanwa, R. C.
Department of Biotechnology, Federal University of Technology, Owerri, Imo State, Nigeria.
Correspondence: *chinwendubueze1@yahoo.com*

Abstract

Globally, palm oil production is on the increase and the pollution caused by waste materials from the palm oil mills has become a major environmental concern. However, not much has been said about the negative effects of such a huge industry. This report reviews the environmental impacts of palm oil mill effluents generated from oil palm processing and how they can be efficiently managed through biotechnological tools. The processing of oil palm generates three (3) major waste streams including gaseous (pollutant gases), liquid (palm oil mill effluent, POME) and solid (palm press fibre, chaff, palm kernel shell and empty fruit bunch) wastes. POME has been the most problematic environmentally, among all the others. It contains high pollution indicators such as oil and grease; it also impacts on the soil and water properties. Discharging POME into the soil tampers withits pH, which is one of the major factors affecting nutrient availability to plants. POME also changes the soil appearance and properties in terms of vegetation, odour, colour and constitution, making the soil to lose its vegetative cover. This leads to water logging of the pores and subsequent death of vegetation, leaving the environment bare. During the rainy season, POME serves a breeding habitat for mosquitoes and produces offensive odours. When discharged into rivers, streams or surrounding lakes, the water turns brown, smelly and slimy, aquatic organisms get killed, and local people are denied the availability of water for domestic uses and fishing. The discharge of POME on the soil and surrounding lands can also contaminate the aquatic ecosystem during runoff, leading to acidification and eutrophication. The paper concludes by suggesting options for effective management such as the use of POME for microalgae cultivation, the use of pre-treated POME as fertilizer; focusing on phytoremediation, bioremediation and mycoremediation of POME-contaminated soil and water as options for the rehabilitation of POME-contaminated soils and water bodies.

Keywords: POME, Management, Biotechnological approaches, Phytoremediation, Bioremediation, Mycoremediation

Introduction

The oil palm industry is one of the major agro industries in some parts of the world such as Malaysia, Indonesia, Thailand, Columbia and Nigeria (Izah and Ohimain, 2016). It has brought about rapid development and economic growth in the producing nations. However, it has contributed to environmental pollution due to the production of large amounts of by-products generated during extraction processes. During the processing of palm oil, three major waste streams are produced: the solid wastes (empty fruit bunch, palm press fibre, chaff and palm kernel shell), the liquid wastes (Palm oil mill effluents POME), and the gaseous emissions (from farm operations in a mechanized farm, agrochemicals and during boiling and digesting).

During the processing of palm oil, a large quantity of water is required. For instance, the production of a tonne of fresh fruit bunch will require about 5.00 -5.75 tonnes of water to produce 10-30% of palm oil, yielding about 50-79% palm oil mill effluents (POME) (Singh *et al*., 2010). POME is composed of wastewater sludge that separates from the oily foam when the palm fruits are being boiled. It is a brown slurry, made up of4-5% organic solids, 0.5-1.0% unrecovered oil, about 95% water, high concentration of organic nitrogen, grease, chemical oxygen demand (COD), and biochemical oxygen demand (BOD) (Rupani *et al*., 2010). Palm oil mill effluents which are not usually treated are discarded into surrounding lands and water bodies and this has led to several environmental problems.

Impact of POME on soil quality

The discharge of POME into the soil affects its pH, which is one of the main factors that influence nutrient availability to plants (Okwute and Isu, 2007). The reason is because, most plants grow and do better within a pH range of 6.5 – 7.5. POME being acidic therefore increases soil acidity. The soil can also be impacted through the leaching of heavy metals and other POME physico-chemical properties into the soil. POME increases organic carbon, total nitrogen, phosphate, sulphate, phosphorus, sodium, potassium, calcium, magnesium, aluminium and hydrogen in the soil (Eze *et al*., 2013). Ordinarily, availability of nutrients including sodium, phosphorus and potassium enhances plant growth. However, high nitrogen, potassium and phosphorus will not be able to perform their functions if the soil pH is abnormal (Okwute and Isu, 2007). The high phosphorus in POME-contaminated soil leads to high absorption of materials thereby delaying its effect on the soil, because POME biodegrades slowly (Okwute and Isu, 2007). Available Phosphorus in soil contaminated with POME is due to increase in pH level and other nutrient determinants available in the soil (Eze *et al*., 2013). The solids in raw POME are good organic matter sources, organic matter being a good booster of soil productivity. However, it is also hindered by the abnormal pH of POME-contaminated soil.

Several organisms invade and grow in soil contaminated with POME, biodegrading complex compounds into simple ones (Okwute and Isu, 2007; Ohimain *et al*., 2012). The changes in the soil physico-chemical properties and other vital nutrients due to POME discharge affects the soil texture and particulate size. POME discharged untreated on the soil increases the soil bulk density, and percentage of silt and clay. The soil texture is usually dependent on the organic matter content. POME discharge on soil leads to water retention due to the presence of unrecovered oil and debris during processing.

Apart from changing the soil appearance, POME also affects some other properties including vegetation, colour, odour, and constitution. Despite the soil enrichment by POME, the soil loses its vegetation cover and becomes damp with humus. This leads to clogging and water logging of the soil pores and eventually result in death of vegetation (Eze *et al*., 2013). Summarily, POME discharge leads to loss of agricultural lands. Also, indigenous microorganisms naturally resident in the soil and some biodiversity such as earthworms, which play significant roles in soil aeration, are lost (Sridhar and AdeOluwa, 2009).

Impact of POME on water quality

In mechanized mills, POME are produced in various processing lines including sterilizers, clarifying centrifuges and hydro cyclones, while in traditional/smallholder mills, they are produced during boiling, digestion and clarification. Most of the POME, especially the ones produced by the small-scale traditional operators undergo little or no treatment and is usually discharged into the surrounding environment (Okwute and Isu, 2007). This often leads to pollution of waterways due to oxygen depletion, reduced land use, and other related effects (Sridhar and AdeOluwa, 2009; Awotoye *et al*., 2011).

During the rainy season, POME is a breeding habitat for mosquitoes and emits offensive odours. Its discharge into the aquatic ecosystem turns the water brown, smelly and slimy (Awotoye *et al*., 2011), which adversely affects aquatic life and water quality for domestic purposes. The discharge of untreated POME into soils also impacts on surrounding water bodies during runoffs, leading to acidification and eutrophication of water bodies. POME can also alter potable water sources (surface and groundwater). According to Awotoye *et al*. (2011), POME increases water parameters such as temperature, pH, total alkalinity, total dissolved solids, total suspended solids, magnesium, calcium, sodium, potassium, chloride, sulphate, nitrate, phosphate, zinc, iron, manganese, dissolved oxygen, biological oxygen demand in a river or water body receiving POME.

Potential options for POME management

The management of oil palm processing wastes is of great importance and should be given utmost priority, because it reduces hazards associated with its processing while generating useful products. The various adverse impacts could be prevented through biotechnological reuse for the liquid wastes with some examples discussed below.

POME can be used to produce organic acids such as acetic and formic acids (Wu *et al*., 2009), citric acids, polyhydroxyalkonates, solvents such as actetonebutanol, bio-insecticides and antibiotics (Wu *et al*., 2009). Others include bio-hydrogen and biogas production (Ohimain and Izah, 2015; Foo and Hameed, 2010; Ohimain and Izah, 2014) through microbial fuel cells technology, composting, vermin-composting (Rupani *et al*., 2010) and fertilizer production due to its ability to enrich the soil phosphorus, nitrogen and potassium content.

When properly treated and packaged, POME can be used by farmers both in rural and urban areas to improve soil fertility thereby increasing the agricultural productivity for global, national and regional food demands (Eze *et al*., 2013). The treatment reduces the initial harsh effects of POME on agricultural lands. The use of pre-treated POME for fertilizer is done through the process of valorisation. Valorisation is any chemical or biotechnological process aimed at recovering value-added products from by-products or wastes (Federici *et al*., 2009). An example of a waste valorisation technology is the vermicomposting process. This is a process for transforming organic waste biologically into compost, which is a nutrient-rich fertilizer and soil conditioner (Lim *et al*., 2015). Vermicomposting involves interactions between earthworms and organic compounds in the waste decomposition process. Earthworms condition and fragment the organic wastes, altering its biological activities for further biochemical decomposition by microorganisms. The potential of vermicomposting to manage a wide variety of biodegradable solid wastes is well documented, such as agro-industrial wastes (Lim *et al*., 2015; Shak *et al*., 2014), industrial wastes (Singh and Suthar, 2012), and municipal wastes (John-Paul *et al*., 2011). The efficiency of vermicomposting process is characterized by earthworm growth, carbon to nitrogen ratio and available nutrients content. Lim and Wu (2015) investigated the evolution of enzyme activities such as dehydrogenase, cellulase, amylase, acid phosphatase, urease and protease during the vermicomposting of POME. The vermicomposting of POME gives the opportunity for resource recovery at lesser costs when compared to other treatment technologies. During the organic waste degradation process, microorganisms decompose organic wastes by producing hydrolytic extracellular enzymes that break down the large organic compounds into smaller fragments. The evolution of enzyme activities during the biodegradation of the organic wastes have been found to be dependent on the growth of the microbial communities present which increase with substrate concentrations. Earthworm activities are also crucial in the promotion of enzymatic activities through increase in substrate availability and activation of microbial metabolism. Therefore, earthworm biomass declines, as well as enzymes thereby resulting to stabilization of organic matters (which can now be used as fertilizer) (Lim and Wu, 2015).

The positive impact of earthworms on bacterial, fungal and Actinomycetes population has also been reported by Singh and Suthar (2012) during the vermicomposting of cow dung and herbal pharmaceutical wastes. The microbes present in the organic wastes were not killed in the intestinal tract of the earthworms instead they increased in the ejected earthworm casts. John-Paul *et al*. (2011) also suggested that earthworms are instrumental in increasing microbial colonization which leads to higher microbial activities and population.

POME can also be used for microalgae production. Generally, the culturing of microalgae on a large scale requires high nitrogen and other related chemical fertilizers, which makes the process non-environmentally friendly. Culturing microalgae in wastewaters has proven to be a very efficient self-purification process for wastewaters (Lam, Lee and Mohammed, 2009). In Malaysia, most palm oil millers favour the culture of microalgae as a tertiary treatment before the POME is released because of the low cost and high impact. The vast majority of the POME nutrients such as nitrates and phosphates that are not removed during the anaerobic digestion is used up in the microalgae pond, playing very important roles in the growth of the microalgae. The cultured microalgae can then be used as feed for livestock (Lam et al., 2009). Other minerals such as Iron, zinc, phosphorus, magnesium, calcium and potassium that are required for microalgae growth are also present in POME.

Thus, the use of POME to grow microalgae for biomass production is a good and low cost option for POME management. Microalgae cultivation in POME also offers an alternative means to the conventional forms of tertiary wastewater treatment because it utilizes the organic compounds present in it to generate the microalgae for biomass production (Lam et al., 2009). However, there are several environmental and operational factors that can affect the microalgae growth in order to make the cultivation fruitful. Thecolloidal, dark and viscous nature of effluent discarded from the palm oil mill are considered in media preparation for culturing the microalgae (Bello *et al*., 2013). According to various researchers, 5% dilution of the raw POME is the best concentration for culture media preparation, due to the natural properties of the POME. This dilution will enhance light penetration into the media for the algal growth.

Through these biotechnological advances, the environmental impact associated with oil palm processing wastes can be effectively managed. However, due to the increasing amount of POME generated, disposal has remained a challenge and this has created the need for the rehabilitation of POME polluted soils and water bodies through biotechnological approaches such as phytoremediation, bioremediation and mycoremediation.

Phytoremediation of POME-contaminated water bodies

Phytoremediation is a green technology and an environmentally friendly approach that makes use of green plants and their associated microorganisms in the reduction of pollutants in water and wastewater. It is an emerging, cost-effective, aesthetically pleasing and low cost technology that directly uses green plants to degrade or render environmental contaminants harmless. These contaminants include organic compounds or heavy metals that the plants are able to take up and accumulate in their tissues (Paz-Alberto and Sigua, 2013). The main application of phytoremediation is in lightly contaminated soils and waters, where the material to be treated is at a shallow or medium depth and the area to be treated large. This will make the technique economical and applicable for both planting and harvesting.

Phytoremediation of POME-contaminated water bodies has so far involved the use of Constructed Wetlands (CW) also known as Artificial Wetlands. Constructed wetlands is a type of phytoremediation system that utilizes the functions of macrophytes and soil media in the domestic, municipal, agricultural and industrial wastewater treatment (Zhang *et al*., 2015). It is a wastewater system constructed to utilize natural processes and remove pollutants from contaminated water and over the years, the system has shown considerable organics and suspended solid removal in wastewater treatment (Vymazal, 2011). Constructed wetlands also promote biodiversity because there is an involvement of soil, water and plant in one system. The selection of suitable plant species is the most important factor in constructed wetland systems.

There are two types of constructed wetlands according to their hydrology; free water surface flow (FWS) and sub-surface flow (SSF) wetlands. Sub-surface flow systems are further divided into horizontal flow (HF) and vertical flow (VF) constructed wetlands according to their flow directions. A combination of two or more wetland systems also known as hybrid constructed wetlands have been shown to enhance treatment performance. Constructed wetlands forces the wastewater to move upwards through the aerobic zone (upper layer), down to the anoxic zone (middle layer) and finally the anaerobic zone (lower layer) (Tee *et al*., 2012).

Phytoremediation in constructed wetlands have been successfully used to remove heavy metals and organic contaminants. The system combines physical, chemical and biological processes to remove pollutants in wastewater. The main mechanisms involve phyto-accumulation, phyto-degradation, phyto-volatilization, phyto-filtration, rhizo-degradation and phyto-desalination (Tahir, Yasmin and Khan, 2015). In the case of heavy metal contaminations, plants take up the contaminants through phytoaccumulation, filtering the metals from water through evatranspiration or phytovolatilization. For organic contaminants, plants take up the contaminants through rhizodegradation (degradation of organic matter in the rhizosphere through the release of enzymes) and phytodegradation (the build-up of organic carbon in the soil).

Plants provide substrates such as roots, stems and leaves for microorganisms that can breakdown the pollutants in the POME-contaminated water, or they clean up the water through uptake of the nutrients and trace metals in the wastewater. In constructed wetland systems, substrates play a great role in the contaminant removal because they provide a suitable growth medium for the plants and also allow successful movement of the wastewater. Substrates are able to remove pollutants from the wastewater by ion exchange, adsorption and precipitation. Substrates also provide the surface area for microbial attachment. The selection of substrates depends on their hydraulic permeability and absorption capacity (Wu, 2015). The absorption capacity influences the loading of the pollutants. Poor hydraulic capacity will result in the clogging of the system, therefore decreasing the effect of the pollutant removal. Clogged substrates are the biggest concern in POME phytoremediation as it can reduce the infiltration of oxygen in the growth media and cause the treatment to fail. The clogging would usually come from the accumulation of solids and oil and grease in the POME. The common substrate in constructed wetland systems may come from natural materials such as gravel, sand, clay, zeolite, limestone or bentonite, or from industrial by-products and agricultural wastes such as rice husk ash, oil palm ash and coal cinder, or artificial products such as activated carbon or compost from agricultural wastes. Gravel is the regularly used substrate in constructed wetland systems because they provide a surface area for the biomass to attach and they also have precipitation capacities. However, a combination of substrates can also be applied.

The selection of suitable plant species is essential in the implementation of phytoremediation of POME-contaminated water (Rezania *et al*., 2015). Suitable plant species for phytoremediation of water polluted by POME should have high uptake ability of organic and inorganic pollutants, fast growth rate, tolerance in polluted water, high adaptability to the climate, and be easily controlled in dispersion (Ali, Khan and Sajad, 2013). Also the plants should not only accumulate, degrade or volatilize contaminants, but should also grow favourably in different conditions and be easy to harvest. The efficiency of phytoremediation also depends on the specie of the plant and their characteristics, interaction of their root zone and environmental conditions. The key roles during implementation of phytoremediation are the rate of photosynthetic activity and the rate of plant growth during the pollutant removal process (Rezania *et al*., 2015). Plant age can also influence the ability of plants to take up the contaminants because young roots will grow faster and have higher nutrient uptake rates than older roots.

Aquatic macrophytes are suitable for wastewater like POME because of their fast growth rate and large biomass and also their ability to take up contaminants in the wastewater (Guittony-Philippe *et al*., 2014). The plants that are able to extract and accumulate pollutants are called Hyperaccumulators. The most common aquatic hyperaccumulators include water hyacinth (*Eichhornia crassipes*), duckweed (*Lemna minor*), water fern *(Azolla filiculoides*), water spinach *(Ipomoea aquatica*), water lettuce (*Pistia stratiotes*), *Cyperus alternifolius*, vetiver grass *(Chrysopogon zizanioides*) and bulrush (*Typha latifolia* and *Scirpus maritimus).*

Indigenous aquatic species such as *Cyperus alternifolius* and *Scirpus maritimus* as emergent plants and *Azolla filiculoides* and *Ipomoea aquatica* as floating plants have been investigated for their potential in the removal of POME contaminants in water. *Cyperus alternifolius* has been found to be the best in phosphorus removal and also in the ability to tolerate unfavourable conditions. It has also been found to be easy to propagate.

Most of the research on phytoremediation of POME to date have used floating plants using species such as water hyacinth (*Eichhornia crassipes*), water lettuce *(Pistia stratiotes)* and Vetiver grass (*Chrysopogon zizanioides*), either with diluted POME samples or pre-treated samples because the high organic and suspended solids content in the raw POME samples are a major problem. The high colloidal POME may clog the surface of the water. Therefore, pre-treatment is required to reduce the suspended solids, oil and grease before feeding into the treatment systems. The potential of emergent plants in the phytoremediation of water contaminated by POME is gradually being explored and Vetiver grass have shown great pollutant removing effects, therefore there is room for the use of other types of emergent plants in POME treatment, putting considerations on their capability to remove the pollutants, their survival rate and how much they tolerate the effluent water.

Vetiver grass in phytoremediation of POME-contaminated water bodies.

Vetiver grass (*Chrysopogon zizanioides*) belongs to the same grass family as maize, sorghum, sugarcane and lemon grass. It is a perennial grass that grows two metres high and three metres deep into the ground.

It has a strong dense and vertical root system. It can grow both in the abundance and in the absence of water. The leaves sprout from the bottom of the clumps and each blade is narrow, long and coarse. The leaf is 45-100cm long and 6-12cm wide. Vetiver grass is highly suitable for phytoremediation because it has some extraordinary features. They include a massive and deep root system, tolerance to extreme climatic variations such as prolonged drought, flood, submergence, fire, frost and heat waves. It also tolerates a wide range of soil acidity, alkalinity, salinity, elevated levels of aluminium, manganese and heavy metals such as arsenic, nickel, lead, zinc, mercury, selenium, copper etc. in soils.

Application of the vetiver grass in phytoremediation of wastewater is still new. It is a green and environmentally friendly approach for treatment of wastewater as well as a natural recycling method. In the process of treatment, the vetiver grass absorbs essential plant nutrients such as nitrogen and phosphorus, and stores them for other uses. The end product of this system of POME treatment has generated high nutrient material for animal feed, mulch for gardens, roof thatching materials, handcrafts (ropes, hats, mats and baskets), raw material for making pulp and paper, and materials for organic farming (Smeal, Hackett and Truong, 2003).

In central China, vetiver grass was used to treat a river polluted with POME withpercentage removal of total phosphorus at 93.7% after two weeks and more than 99% after three weeks (Tahir *et al*., 2015). According to the same research, thepercentage removal of total nitrogen was 58% after two weeks and 71% after four weeks. Phosphorus is a very key element in water eutrophication. Thus, vetiver grass can be used for the rehabilitation of soils and water polluted with POME, which are often extremely acidic, high in heavy metals and high in plant nutrients (that cannot be adequately used by the vegetation due to abnormal pH).

Bioremediation of POME-polluted soil

In natural conditions, pollutants in the environment are degraded slowly. This means that a lot of harm will be done to the ecosystem before such an environment recovers. Therefore, there is the need to speed up the rate of recovery of the polluted environment. Bioremediation is any process that uses microorganisms, their enzymes and green plants to return the altered contaminated environment to its original condition (Khan, 2011). Microorganisms alter and break down the oil into other substances such as carbon dioxide, water and simpler compounds that do not affect the environment. The rate at which the soil recovers will depend on the type of contaminants present and how long they have been there. POME which contains long chain hydrocarbons in addition to unrecovered oil makes it necessary to hasten the period of recovery of the soil. Bioremediation has been used to successfully clean up petroleum hydrocarbon pollutants (Okoh, 2006), refinery effluents (Ojumu *et al*., 2005), textile effluents (Bako, Chukwunonso and Adamu 2008) and wastewater (Okonko and Shittu, 2007).

The bioremediation of POME depends enormously on a combination of microbial activities that will use up the organic substances present in the POME as supplements for their own growth and eventually degrade the organic matters into simple by-products such as methane, carbon dioxide, hydrogen sulphide and water. The bioremediation process would require a large pond to hold the POME in place for effective biodegradation, which will regularly take a few days depending on the nature of the microorganisms (Wu *et al*., 2010). A variety of microorganisms have been investigated and found to be capable of degrading oily waste water. Anaerobic and aerobic treatments have been the long-standing biological treatments for POME but the suspended and colloidal components are not usually effectively decomposed because their floating nature affects the microbial cycle. This usually causes failure of the treatment system, giving rise to the need for a more effective treatment mechanism for the liquid wastes. Apart from this, the presence of spores makes the microbial species present in POME to be inactive and highly resistant to the lethal effect of boiling, dry heating and ultra violet radiation, the spores also enable them to survive the high acidity of POME environment (Okechalu *et al*., 2011).

Okwute and Ijah (2014), detected the presence of various microorganisms such as *Pseudomonas aeruginosa*, *Aspergillus*, *Penicillum* and *Candida* in chicken droppings and cow dung with the ability to break down oil and this was found to speed up the bioremediation process in POME-polluted soil.

The use of fungi (mycoremediation) in the rehabilitation of POME-polluted soil.

The use of fungi in the bioremediation of POME has drawn the attention of researchers for some time now.

This is because most of the previous works in the bioremediation of POME has so far involved only bacteria. Several fungi like *Rhizopus*, *Mucor*, *Candida rugosa*, *Geotrichum candidum* and *Aspergillus* have been studied for their abilities to produce lipolytic enzymes (Nwauche and Ogbonna, 2011). Lipolytic enzymes like lipase facilitate the hydrolysis of lipids, causing their breakdown into fatty acid and alcohol. The oily nature provides a good environment for lipolytic microorganisms to flourish due to the unrecovered oil present in the POME. *Aspergillus niger* and *Aspergillus flavus* have been especially distinguished for their ability to endure oily waste water such as POME. The presence of *Penicillum*, *Fusarium* and *Mucor* sp. in POME, have also shown that these fungi are able to survive in hostile environments (Ohimain *et al*., 2012; Nwuche and Ogbonna, 2011). According to previous reports, these organisms can degrade oily water effectively. High population of fungi in POME may be attributed to poor sanitation in the traditional and smallholder mills.

Biodegradation of POME by fungi has to do with the saprophytic ability of the fungi to grow on and degrade carbon sources in the POME and also reduce factors which could influence the environment. Therefore, the screening and isolation of fungi from POME dump sites provides an alternative and environmentally friendly way of cleaning up the pollutants because the microbes use the organic compounds present in the POME as supplements, thereby degrading them into simpler compounds.

Lanka and Pydipalli (2018), in India, investigated selected fungal strains isolated from POME dump sites in the bioremediation of POME. The fungal isolates showed very high lipase producing activities. The reduction efficiency in the removal of oil and grease was highest with *Emericella nidulans* and lowest in *Trichoderma reesei*, indicating the potential of these indigenous fungal strains in the removal of oil and grease. The organisms were also found to be effective in the reduction of chemical oxygen demand (COD) and biological oxygen demand (BOD) from the POME. This is very important because high BOD and COD makes POME unsuitable for discharge into the environment, therefore recycling of POME by biological treatment using these organisms will make the POME safe for discharge and/or reuse.

The use of other fungi such as *Trichoderma viride* and yeast such as *Saccharomyces cerevisae* and *Yarrowia lipolytica* for the treatment of POME has not been extended to the removal of oil and grease even though they have high potentials in the removal of chemical oxygen demand (COD) from POME (Jameel and Olanrewaju, 2011). This may be because these microorganisms are not indigenous to POME. The fact that physical or chemical treatment of the raw POME is not required is also an added advantage in the use of indigenous fungi for POME bioremediation.

Conclusion

The problem of palm oil mill effluent pollution is unique to Nigeria for a number of reasons. No established control methods are effective because local palm oil mills located in the nooks and crannies are unlicensed and without quality control. Palm oil mill effluent treatment technology is non-existent and the prescribed environmental regulations on the allowable pollution loads are unenforceable. Minimization of effluent quantity is not pursued in the traditional palm oil mill and effluent utilization is also not practiced. Sound water quality objectives to reduce the level of pollutants in the effluents are not pursued due to lack of awareness of the severity of the pollution problem being created.

This prevalent disregard for the environment in Nigeria with regard to indiscriminate effluent discharge is far from the desired as most industries in developed countries strive for quality and environmental conservation through sustainable development and cleaner technology approaches (Awotoye *et al.,* 2011).

Some of the major obstacles to adoption of cleaner solutions in POME management in palm oil mills have been the total absence of sustainable technology and compelling economic arguments. There are reasons why POME has been treated and handled by millers as waste instead of resource. This report has suggested some options for effective POME management. Therefore, POME should be considered a valuable resource, and recovering it for other uses is a much more preferable environmental alternative than the current way it is treated and disposed of.

However, as disposal and discharge has remained a challenge, phytoremediation, bioremediation and mycoremediation technologies have proved to be low-cost, effective methods of removing the pollutants and making the polluted soil and water once again fit for domestic, agricultural and industrial uses.

References

Ali, H., Khan, E. and Sajad, M. A. (2013). Phytoremediation of heavy metals-Concepts and applications. **pp**. 869–881.

Ahmed, Y., Yaakob, Z., Akhtar, P. and Sopian, K. (2015). Production of biogas and performance evaluation of existing treatment processes in palm oil mill effluent (POME). *Renewable and Sustainable Energy Reviews*. **42:** 1260–1278.

Awotoye, O. O., Dada, A. C. and Arawomo, G.A.O. (2011). Impact of Palm Oil Processing Effluent Discharge on the Quality of Receiving Soil and River in South Western Nigeria. *Journal of Applied Science Research.* **7(2)**: 111-118.

Aziz, A. H. (2007). Reactive extraction of sugars from oil palm empty fruit bunch hydrolysate using Naphthalene-2-Boronic acid [Doctoral dissertation]. University of Science, Malaysia.

Bako, S. P., Chukwunonso, D. and Adamu, A. K. (2008). Bioremediation of refinery effluents by strains of *Pseudomonas aeruginosa* and *Penicillium janthinellum*. *Applied Ecologyand Environmental Research*. **6(3)**: 49-60.

Bello, M. M., Nourouzi, M. M., Abdullah, L. C., Choong, T. S., Koay, Y. S. and Keshani, S. (2013). POME is treated for removal of colour from biologically treated POME in fixed bed column: Applying wavelet neural network (WNN). *Journal of Hazardous Materials*. **262:** 106-113.

Cameotra, S. S. and Singh, P. (2008). Bioremediation of oil sludge using crude biosurfactants. *International Biodeterioration and Biodegradation*. **62(3):** 274–280.

Edward, J. B., Idowu, E. O. and Oyebola, O. E. (2015). Impact of pam oil mill effluent on physic-chemical parameters of a southwestern River, Ekiti state, Nigeria. *Journal of Natural Sciences Research***. 4(14):** 26 – 30.

Embrandiri, A., Singh, R. P., Ibrahim, H. M. and Ramli, A.A. (2012). Land application of biomass residue generated from palm oil processing: its potential benefits and threats. *Environmentalist*. **32(17):** 111 – 117.

Eze, V. C., Owunna, N. D. and Avoaja, D. A (2013). Microbiological and physicochemical characteristics of soil receiving palm oil mill effluent in Umuahia, Abia State, Nigeria. *Journal of Natural Sciences Research***3**: 163-169.

Foo, K. Y. and Hameed, B. H. (2010). Insight into the applications of palm oil mill effluent: A renewable utilization of the industrial agricultural wastes. *Renewable and Sustainable Energy Review*. **14**: 1445 – 1452.

Federici, F., Fava, F., Kalogerakis, N. and Mantzavinos, D. (2009). Valorisation of agroindustrial by-products, effluents and waste: concept, opportunities and the case of olive mill wastewaters. *Journal Chemical Technology and Biotechnology*.**84**: 895-900.

Fresh oil palm fruits. (2019). Available at www.shutterstock.com Retrieved on 01/02/2019.

Guittonny-Philippe, A., Masotti, V., Höhener, P., Boudenne, J. L., Viglione, J. and Laffont-Schwob, I. (2014). Constructed wetlands to reduce metal pollution from industrial catchments in aquatic Mediterranean ecosystems: A review to overcome obstacles and suggest potential solutions. *Environment International*. **64**: 1–16.

Hambali, E., Thahar, A. and Komarudin, A. (2010). The potential oil palm and rice biomass as bioenergy feedstock. 7th Biomass Asia Workshop, November 29 – December 01, 2010, Jakarta, Indonesia.

Ibiene, A. A., Orji, F. A., Ezidi, C. O. and Ngwobia, C. L. (2011). Bioremediation of hydrocarbon contaminated soil in the Niger delta using spent mushroom compost and other organic wastes. *Nigerian Journal of Agriculture, Food and Environment*. **7(3):** 1 – 7.

Izah, S. C., Oduah, A. A. and Ohimain, E. I. (2014). Effects of Temperature and fermentation period on the recovery of second grade palm oil from palm press fiber. *International Journal of Engineering Science and Innovative Technology*. **3(5):** 131-138.

Izah, S. C. and Ohimain, E. I. (2015). Bioethanol production from cassava mill effluents supplemented with solid agricultural residues using bakers' yeast [*Saccharomyces cerevisiae*]. *Journal of Environmental Treatment Techniques*. **3(1):** 47 – 54.

Izah, S. C., Ohimain, E. I. and Angaye, T. C. N. (2016) Potential thermal energy from palm oil processing solid wastes in Nigeria: mills consumption and surplus quantification. *British Journal of Renewable Energy*.**1(1):** 38 – 44.

Izah, S. C. and Ohimain, E. I. (2016). Microbiological quality of palm oil used in Nigeria: Health impacts perspective. *Point Journal of Botany and Microbiology Research*. **2(1):** 037 – 045.

Jameel, A. T. and Olanrewaju, A. A (2011). Aerobic biodegradation of oil and grease in palm oil mill effluent using consortium of microorganisms. Current research and development in biotechnology engineering at International Islamic University Malaysia (IIUM), IIUM Press, Kuala Lumpur. **pp**. 43 – 51.

John Paul, J. A., Karmegam, N. and Daniel, T. (2011). Municipal solid waste (MSW) vermicomposting with an epigeic earthworm, *Perionyx ceylanensis.BioresourceTechnology*.**102:** 6769-6773.

Kadlec, R. H. (2009). Comparison of free water and horizontal subsurface treatment wetlands. *Ecological Engineering*. **35(2)**: 159–174.

Khan, F.A. (2011). Biotechnology fundamentals. Boca Raton, Florida: CRC Press, Taylor and Francis Group. **pp**. 245.

Lam, M. K, Lee, K. T. and Mohamed, A. R. (2009). Life cycle assessment for the production of biodiesel: A case study in Malaysia for palm oil versus jatropha oil. *Biofuels*, *Bioproducts and Biorefining*. **3(6):**601-612.

Lanka, S. and Pydipalli, M. (2018). Reduction of organic load from palm oil mill effluents (POME) using selected fungal strains from POME dump sites. *African Journal of Biotechnology*. **17(36):** 1138-1145.

Lim, P. N., Wu, T. Y., Clarke, C., and Nik-Daud, N. N. (2015). A potential bioconversion of empty fruit bunches into organic fertilizer using *Eudrilus eugeniae*. *International Journal of Environmental Science and Technology*. **12:** 2533-2544.

Nwauche, C. O. and Ogbonna, J. C. (2011). Isolation of lipase producing fungi from palm oil mill effluents (POME) dump sites at Nsukka. *Brazilian Archives of Biology andTechnology*.**54(1):** 113-116.

Nwaugo, V. O., Chinyere, G. C. and Inyang, C. U. (2008). Effects of palm oil mill effluents (POME) on soil bacterial flora and enzyme activities in Egbema. *Plant Production Research Journal*. **12:** 10 – 13.

Ohimain, E. I., Olukole, C. D., Izah, S. C., Eke, R. A. & Okonkwo, A. C. (2012). Microbiology of Palm Oil Mill Effluents. *Journal of Microbiology and Biotechnology Research*. **2(6):** 852-857.

Ohimain, E. I., Daokoru-Olukole, C., Izah, S. C. and Alaka, E. E. (2012). Assessment of the quality of crude palm oil produced by smallholder processors in Rivers State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*.**8(2):** 28 - 34.

Ohimain, E. I., Seiyaboh, E. I., Izah, S. C., Oghenegueke, V. E. and Perewarebo, T. G. (2012). Some selected physico-chemical and heavy metal properties of palm oil mill effluents. *Greener Journal of Physical Sciences*. **2(4):** 131 - 137.

Ohimain, E. I., Daokoru-Olukole, C., Izah, S. C., Eke, R .A. and Okonkwo, A .C. (2012) Microbiology of palm oil mill effluents. *Journal of Microbiology and Biotechnology Research*. **2(6):**852 – 857.

Ohimain, E. I., Izah, S. C. and Obieze, F. A. U. (2013). Material-mass balance of smallholder oil palm processing in the Niger Delta, Nigeria. *Advanced Journal of Food Science and Technology*. **5(3):** 289-294.

Ohimain, E. I. and Izah, S. C. (2013). Gaseous emissions from a semi-mechanized oil palm processing mill in Bayelsa state, Nigeria. *Continental Journal of Water, Air and SoilPollution*. **4 (1):** 15 – 25.

Ohimain, E. I. and Izah, S. C. (2013). Water minimization and optimization by small-scale palm oil mill in Niger Delta, Nigeria. *Journal of Water Research*. **135:** 190 – 198.

Ohimain, E. I., Izah, S. C. and Abah, S. O. (2013). Air quality impacts of smallholder oil palm processing in Nigeria. *Journal of Environmental Protection*. **4:** 83-98.

Ohimain, E. I., Izah, S. C. and Jenakumo, N. (2013). Physicochemical and microbial screening of palm oil mill effluents for amylase production. *Greener Journal of Biological Sciences*. **3(8):** 314 – 325.

Ohimain, E. I. and Izah, S. C. (2014). Possible contributions of palm oil mill effluents to greenhouse gas emissions in Nigeria. *British Journal of Applied Science and Technology*.**4(33):** 4705 – 4720.

Ohimain, E. I. and Izah, S. C. (2014). Potential of Biogas Production from Palm Oil Mills’ Effluent in Nigeria. *Journal Sky of Soil Sciences and Environmental Management*. **3(5):** 50 – 58.

Ohimain, E. I. and Izah, S. C. (2015). Estimation of potential Biohydrogen from Palm Oil Mills’ Effluent in Nigeria using different microorganisms under light independent fermentation. *Journal of Environmental Treatment Techniques*. **3(2):**97 – 104.

Ojumu, T. V., Bello, O. O., Sonibare, J. A and Solomon, B. O. (2005). Evaluation of microbial systems for bioremediation of petroleum refinery effluents in Nigeria. *African Journal of Biotechnology*. **4(1)**: 31-35.

Okechalu, J. N., Dashen, M. M., Lar, P. M., Okechalu, B. and Gushop, T. (2011). Microbiological quality and chemical characteristics of palm oil sold within Jos metropolis, Plateau State, Nigeria. *Journal of Microbiology and Biotechnology Research*. **1(2):** 107 - 112.

Okoh, A. I., (2006). Biodegradation alternative in the clean-up of petroleum hydrocarbon pollutants. *Biotechnology and Molecular Biology Review*. **1(2):** 38-50.

Okonko, I. O. and Shittu, O. B. (2007). Bioremediation of wastewater and municipal water treatment using latex from *caloptropisprocera* (Sodom Apple). *Electronic Journal of Environmental, Agricultural and Food Chemistry*. **6(3):** 1890-1904.

Okwute, O. L. and Isu, N. R. (2007). Impact analysis of palm oil mill effluent on the aerobic bacterial density and ammonium oxidizers in a dumpsite in Anyigba, Kogi State. *African Journal of Biotechnology*.**6(2):** 116-119.

Okwute, O. L. and Ijah, U. J. (2014). Bioremediation of palm oil mill effluent (POME) polluted soil using microorganisms found in organic wastes. *The International Journalof Biotechnology*. Available at http://www.pakinsight.com/?ic=journal&journal=57 Retrieved on 29th March, 2019.

Okwute, O. L. and Isu, N. R. (2007). The environmental impact of palm oil mill effluents (POME) on some physico-chemical parameters and total aerobic bioload of soil at a dump site in Anyigba, Kogi State, Nigeria. *African Journal of Agricultural Research*. **2(12):** 656-662.

Olagunju, F. I. (2008). Economics of palm oil processing in South Western Nigeria. *International Journal of Agricultural Economics and Rural Development.***1(2):** 69-77.

Paz-Alberto, A. M., &Sigua, G. C. (2013). Phytoremediation: A green technology to remove environmental pollutants. *American Journal of Climate Change*. **2:** 71.

POME generated by a mechanized oil palm mill. (2019). Available at www.scialert.net Retrieved on 01/02/2019.

Rezania, S., Ponraj, M., Talaiekhozani, A., Sabbagh, F. and Sairan, F. (2015). Perspectives of phytoremediation using water hyacinth for removal of heavy metals, organic and inorganic pollutants in wastewater. *Journal of Environmental Management*. **163:** 125–133.

Rupani, P. F., Singh, R. P., Ibrahim, H. and Esa, N. (2010). Review of current palm oil mill effluent (POME) treatment methods: vermicomposting as a sustainable practice. *World Applied Sciences Journal*. **11 (1):** 70 - 8I.

Sen, B. and Chandra, T. S. (2009). Do earthworms affect dynamics of functional response and genetic structure of microbial community in a lab-scale composting system. *Bioresource Technology*.**100:** 804-811.

Shak, K. P. Y., Wu, T. Y., Lim, S. L. and Lee, C. A. (2014). Sustainable reuse of rice residues as feedstocks in vermicomposting for organic fertilizer production. *Environmental Science and Pollution Research*. **21:** 1349-1359.

Singh, D. and Suthar, S. (2012). Vermicomposting of herbal pharmaceutical industry waste: Earthworm growth, plant-available nutrient and microbial quality of end materials. *Bioresource Technology*. **11:** 179-185.

Singh, R. P., Ibrahim, M. H., Norizan, E. and Iliyana, M. S. (2010). Composting of waste from palm oil mill: a sustainable waste management practice. *Reviews in Environmental Science and Biotechnology*. 331 – 344.

Singh, R. P., Embrandiri, A., Ibrahim, M. H. and Esa, N. (2011). Management of biomass residues generated from oil mill: vermicomposting a sustainable option. *Resources, Conservation and Recycling*. **55:** 423-434.

Smeal, C., Hackett, M. and Truong, P. (2003). Vetiver system for industrial wastewater treatment in Queensland, Australia, in Proceedings of the 3rd International Conference on Vetiver and Exhibition, Guangzhou, China.

Sridhar, M. K. C.andAdeOluwa, O. O. (2009). Palm Oil Industry Residue. Biotechnology for Agro-industrial Residues Utilisation, Nigam, P. S and Pandey, A. (eds.). Springer Science. **pp**. 341 – 355.

Soleimaninanadegani, M. and Manshad, S. (2014). Enhancement of Biodegradation of Palm Oil Mill Effluents by Local Isolated Microorganisms. *International Scholarly Research Notices*. **pp**. 1 – 8.

Tahir, U., Yasmin, A. and Khan, U. H. (2015). Phytoremediation: Potential flora for synthetic dyestuff metabolism. *Journal of King Saud University – Science*. **91:** 1-12.

Tee, H. C., Lim, P. E., Seng, C. E. and Nawi, M. A. (2012). Newly developed baffled subsurface-flow constructed wetland for the enhancement of nitrogen removal. *Bioresource Technology*. **104**: 235–242.

The oil palm- *Elaeisguineensis*. (2019). Available at https://en.wikipedia.org/wiki/Elaeis_guineensis 2019 Retrieved on 02/01/2019.

Truong, P. (2008). Research and development of the vetiver system for treatment of polluted water and contaminated land. Paper presented at the TVN India 1st Workshop Proceedings.

Vetiver grass- *Chrysopogon zizanioides*. (2019). Available at https://en.m.wikipedia.org/wiki/Chrysopogon_zizanioides Retrieved on 01/02/2019.

Vymazal, J. (2011). Plants used in constructed wetlands with horizontal subsurface flow: A review. *Hydrobiologia*. **674(1):** 133–156.

Wattanapenpaiboon, N. and Wahlqvist, M. L. (2003). Phytonutrient deficiency: the place of palm fruit. *Asia Pacific Journal of Clinical Nutrition*. **12(3):**363 – 368.

Wong, K. M., Nor, A. A., Suraini, A., Vikineswary, S. and Mohd, A. H. (2008). Enzymatic hydrolysis of palm oil mill effluent solid using mixed cellulases from locally isolated fungi. *Research Journal of Microbiology*. **3(6):** 474-481.

Wu, T. Y., Mohammad, A. W., Jahim, J. and Anuar, N. (2010). Pollution control technologies for the treatment of palm oil mill effluent (POME) through end-of-pipe processes. *Journal of Environmental Management*. **91(7):**1467–1490.

Wu, T. Y., Mohammad, A. W., Jahim, J. and Anuar, N. (2009). A holistic approach to managing palm oil mill effluent (POME): Biotechnological advances in thesustainable reuse of POME. *Biotechnology Advances*.**27(1):** 40-52.

Wu, S. (2015). Treatment of industrial effluents in constructed wetlands: Challenges, operational strategies and overall performance. *Environmental Pollution*. **201:**107–120.

Zhang, D. Q., Jinadasa, K. B., Gersberg, R. M., Liu, Y., Tan, S. K. and Ng, W. J. (2015). Application of constructed wetlands for wastewater treatment in tropical and subtropical regions. *Journal of Environmental Sciences*. **30:** 30–46.

Access this Article in Online

Website:
www.ijarbs.com

Subject:
Biotechnology

Quick Response Code

DOI:10.22192/ijarbs.2020.07.07.014

How to cite this article:

Okereke, J. N. and Ginikanwa, R. C. (2020). Environmental impact of palm oil mill effluent and its management through biotechnological approaches. Int. J. Adv. Res. Biol. Sci. 7(7): 117-127.

DOI: http://dx.doi.org/10.22192/ijarbs.2020.07.07.014