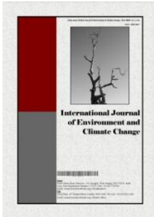

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Influence of Solar Energy on the Physicochemical Parameters of Effluent Sludge and the Receiving Stream of an Oxidation Pond

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Authors' contributions

This work was carried out in collaboration between both authors. Author FOO designed the study, wrote the protocol and wrote the first draft of the manuscript. Author AOO managed the analyses of the study, the literature searches and statistical analysis. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: This study was aimed at determining the physicochemical characteristics (such as pH, dissolved oxygen, biological oxygen demand, nitrogen, phosphorus, chloride, iron, lead, magnesium etc.) of the effluent sludge from a sewage oxidation pond and the receiving stream before and after exposure to solar energy. This is to gain a better understanding on how ultraviolet radiations from sunlight alters the physicochemical parameters inherent in the sludge and the stream.

Methods and Results: Effluent sludge samples and water samples from the receiving stream were collected and exposed to solar energy over a twenty-day period. Physicochemical parameters were measured using standard methods. Results revealed that mean values of dissolved oxygen and pH increased whereas those of biological oxygen demand, ammonia nitrogen, chloride, phosphorus, iron, lead zinc and magnesium reduced over the period study.

Conclusion: The findings from this study suggest that the addition of solar energy to the chains of processes in sewage treatment will produce effluents with minimal content of nutrients from organic matter and heavy metals and these will ultimately protect the receiving stream from contamination, thus contributing to human health protection.

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Keywords: Sewage oxidation pond; sunlight; wastewater treatment; physicochemical characteristics; heavy metals; organic matter.

1. INTRODUCTION

Sewage oxidation ponds are constructed lagoons with a depth of three to five feet, in which sunlight, oxygen, algae, bacteria, protozoa and other organisms interact to purify and improve the quality of the water. The maintenance and operational requirements of sewage oxidation ponds generally qualifies it as a low-cost method that is applicable in low resource settings for treating sewage from small communities [1].

Sewage, industrial and municipal wastes that are untreated or partially treated are continuously discharged into aquatic environments. This alters the physicochemical characteristics of the receiving waters and thus, renders it unfit for drinking, bathing, irrigation purposes or recreational activities [2].

Uncontrolled discharge of domestic wastewater into ponds, oftentimes, lead to eutrophication of ponds and depletion of dissolved oxygen in the ponds [3]. The solid component of sewage (sludge) contains biodegradable organic materials with significant inorganic matter and exhibit wide variation in the physical, chemical and biological properties [4]. Partially treated effluents from sewage oxidation ponds usually contain certain concentration of nutrients, sediments, toxic substances and pathogenic microorganisms that may have a negative impact on the quality and life forms of the receiving waters [5]. Untreated or partially treated wastewater is a major source of contamination of surface waters [6]. It contributes elements such as phosphorus, nitrogen and potassium to receiving waters. Phosphorus stimulates the growth of microscopic plant and nitrogen promotes overgrowth of aquatic vegetation that degrades the quality of the receiving waters while potassium promotes productivity of aquatic animals such as fish [7].

Physicochemical parameters (such as temperature, pH, dissolved oxygen, salinity, turbidity, electrical conductivity etc.) have been demonstrated to influence biochemical reactions in aquatic environments [8]. Organic matter in effluents (containing carbon, nitrogen and phosphorus) promote the growth of zooplankton as well as macro benthic invertebrates [9].The growth of decomposers such as bacteria and fungi are also stimulated by the presence of the organic matter. Bacteria and fungi are very critical to the breakdown of the toxic compounds in effluents from sewage oxidation ponds. It has been demonstrated that dissolved oxygen is often depleted during the process of decomposition of the organic matter, and this may result into accumulation of harmful substances [10].

Organic matter containing high concentration of ammonia may occur as bubbles attached to the block solid materials known as benthic deposit. Most surface waters flowing through heavily urbanized and industrialized areas are contaminated with high concentration of heavy metals of variable and unsuitable physicochemical characteristics [11]. The presence of toxic metals such as lead (Pb) and cadmium (Cd) in the environment and nutrient such as nitrate in drinking water pose significant risk to human health. Studies have linked the presence of nitrate in drinking water to blood disorder methamoglobinaemia among bottle-fed infants (blue baby syndrome), and increased risk of cancer and adverse reproductive outcomes in adults [12,13].

This study was aimed at determining the physicochemical characteristics of the effluent sludge from a sewage oxidation pond and the receiving stream before and after exposure to solar energy. This is to gain a better understanding on how ultraviolet radiations from sunlight alters the physicochemical parameters inherent in the sludge and the stream.

2. MATERIALS AND METHODS

2.1 Study Area

The oxidation pond is located at Obafemi Awolowo University, Ile Ife. It is situated in the southwest area within the University campus to enhance easy draining of sewage from the students' hostels, academic area and staff residence of about 30,000 populations. The size of the pond is 150 × 32 × 1.5 metres and receives wastewater influent through sewers made of concrete pipes and there are manholes sited at some points along the channels to change the direction of the sewers.

2.2 Sample Collection

Samples were collected from the oxidation pond and the receiving stream which flows into the

Opa River. Sludge samples were collected at the outlet of the pond with shovel into an air-tight transparent plastic container while water samples were collected at the discharge point into the receiving stream with a clean sterile five litre bottle. The samples were transported in a cool box to the laboratory within one hour for analyses.

2.3 Exposure to Sunlight

The sludge samples and the water samples from the receiving stream were exposed to solar energy for a period of 20 days.

2.4 Measurement of Physiochemical Characteristics of the Samples

The physicochemical parameters of both samples were determined before (i.e. on day 0) and after (i.e. on day 10 and day 20) exposure to solar energy. For each physicochemical parameter, 1% of the effluent sludge was reconstituted in 10 ml distilled water. The pH was measured using pH meter (MP 230) following standardization with appropriate buffers. The biological oxygen demand (BOD) was determined by measuring the amount of dissolved oxygen present in the samples before and after incubation in the dark at 20ºC for five days [14]. The dissolved oxygen (DO) was measured using titration method. Phosphate, nitrate, chloride and heavy metal content (such as iron, lead, magnesium and zinc) were determined using standard methods [14].

2.5 Statistical Analysis

Data obtained were subjected to single factor analysis of variance (ANOVA) at 95% confidence level while significant means were separated with the New Duncan's Multiple Range Test (NDMRT). In addition, descriptive statistics was carried out using Statistical Package for Social Sciences (SPSS) version 20.0.

3. RESULTS

3.1 Physicochemical Parameters of Effluent Sludge and the Receiving Stream

The values of all the physicochemical parameters observed in both the effluent sludge and the receiving stream after exposure to the effect of solar energy at ten days' interval are presented in Figs. 1 to 7 and Table 1.

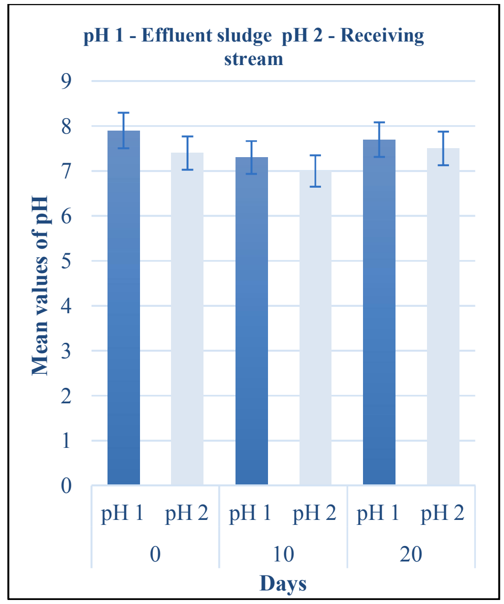

Fig. 1. Effect of sunlight on pH of effluent sludge (pH 1) and the receiving stream (pH 2) with increase in days

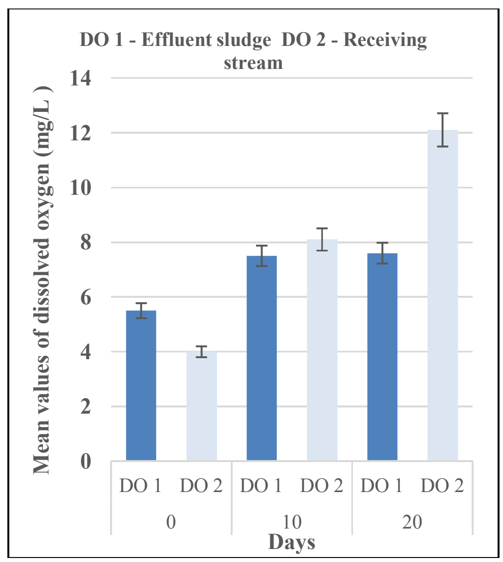

Fig. 2. Effect of sunlight on dissolved oxygen in effluent sludge and the receiving stream with increase in days

The pH values in both effluent sludge and the receiving stream reduced over the first few days after exposure to sunlight, but increased steadily in the subsequent days until the twentieth day of exposure to sunlight. The pH values ranged from 6.9 to 7.9 in both effluent sludge and the receiving stream (Fig. 1). The amount of dissolved oxygen in both effluent sludge and the receiving stream increased gradually over the period of exposure to sunlight. It ranged from 4.0 to 12.1 mg/L in both effluent sludge and the receiving stream (Fig. 2).

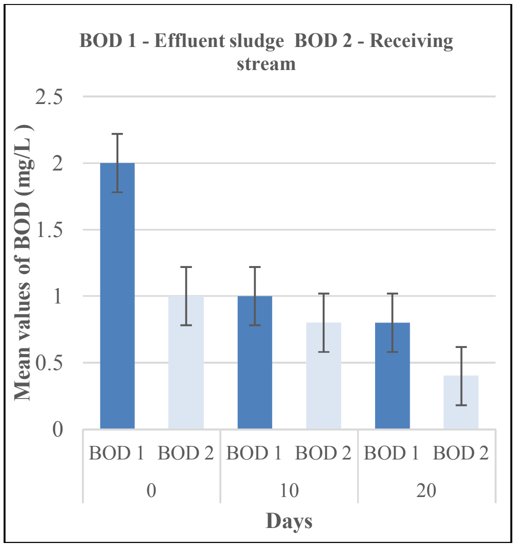

Fig. 3. Effect of sunlight on biological oxygen demand in effluent sludge and the receiving stream with increase in days

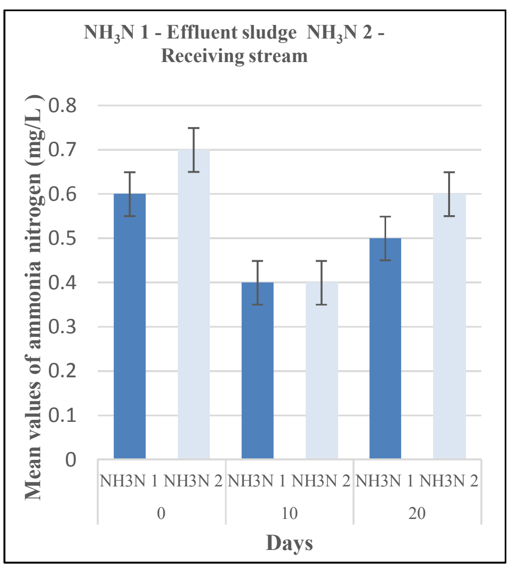

Fig. 4. Effect of sunlight on concentration of ammonia nitrogen in effluent sludge and the receiving stream with increase in days

The biological oxygen demand in both effluent sludge and the receiving stream reduced gradually over the twenty-day exposure period to sunlight. The values ranged from 0.4 to 2.0 mg/L in both effluent sludge and the receiving stream (Fig. 3). The concentration of ammonia nitrogen in both effluent sludge and the receiving stream reduced over the first few days after exposure to sunlight, but increased steadily in the subsequent days until the twentieth day of exposure to sunlight. The values ranged from 0.4 to 0.7 mg/L (Fig. 4). Similarly, the concentration of nitrogen in both effluent sludge and the receiving stream reduced gradually over the twenty-day exposure period to sunlight. The values ranged from 2.6 to 3.7 mg/L in both effluent sludge and the receiving stream (Fig. 5).

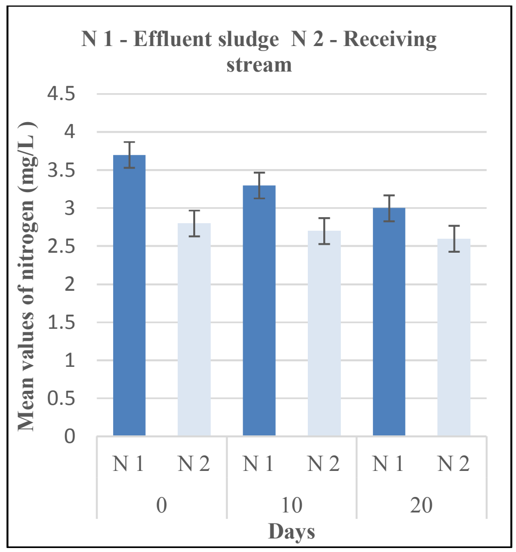

Fig. 5. Effect of sunlight on concentration of nitrogen in effluent sludge and the receiving stream with increase in days

The concentration of phosphorus in both effluent sludge and the receiving stream reduced gradually over the twenty-day exposure period to sunlight. The values ranged from zero to 3.0 mg/L in both effluent sludge and the receiving stream (Fig. 6). The concentration of chloride in both effluent sludge and the receiving stream increased over the first few days after exposure to sunlight, but reduced gradually in the subsequent days until the twentieth day of exposure to sunlight. The values ranged from 3.7 to 22.0 mg/L in both effluent sludge and the receiving stream (Fig. 7). The concentration of the magnesium in both effluent sludge and the receiving stream, zinc in receiving stream, iron and lead in the effluent sludge reduced gradually over the study period, whereas the concentration of iron in the receiving stream and zinc in the effluent sludge increased steadily over the twenty-day period of exposure to sunlight (Table 1).

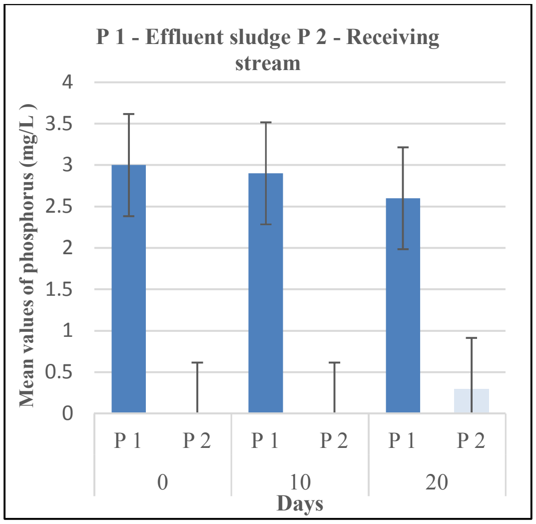

Fig. 6. Effect of sunlight on concentration of phosphorus in effluent sludge and the receiving stream with increase in days

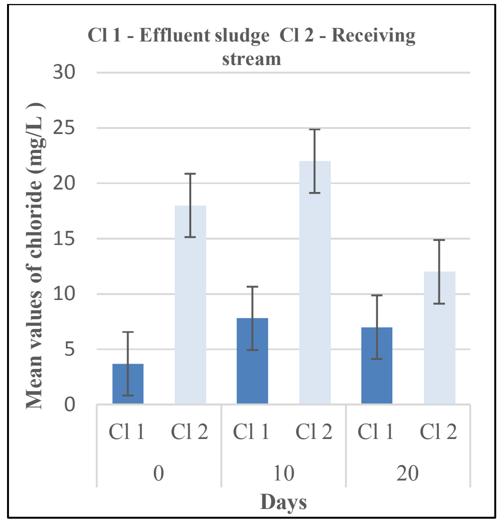

Fig. 7. Effect of sunlight on concentration of chloride in effluent sludge and the receiving stream with increase in days

Table 1. Effect of sunlight on concentration of heavy metals in effluent sludge and the receiving stream with increase in days

Days	Heavy metals							
	Iron		Lead		Magnesium		Zinc	
	ES	RS	ES	RS	ES	RS	ES	RS
0	10.93c±0.03	0.04a±0.01	0.14a±0.01	ND	113.12c±0.23	94.83c±0.03	0.08a±0.00	0.42a±0.16
10	8.68b±0.03	0.18a±0.00	ND	ND	102.10b±0.18	86.00b±0.12	0.09a±0.00	0.32a±0.08
20	6.09a±0.01	0.20a±0.00	0.02a±0.00	ND	91.08a±0.13	77.17a±0.20	0.10a±0.00	0.22a±0.00

Key: Values are mean ± standard deviation; ND – Non detect; ES – Effluent Sludge; RS – Receiving stream; values with superscripts show test of significance at 95% confidence interval

4. DISCUSSION

The pH values in both the effluent sludge and the receiving stream varied from slightly acidic to slightly alkaline. This may be as a result of the nature of the compounds present in the effluent sludge, which also influenced the pH values in the receiving stream. This pH values are suitable for the growth and survival of most microorganisms. In this study, the biological oxygen demand was higher in the effluent sludge compared to those in the receiving stream, whereas the amount of dissolved oxygen was higher in the receiving stream than those in the effluent sludge, although, the reverse was the case initially i.e., those in the effluent sludge were higher those in the receiving stream. This may be because of the higher rate of utilization of dissolved oxygen by microorganisms in the effluent sludge compared to the receiving stream. This observation is in agreement with Olutiola, et al. (2012) where the authors demonstrated that the amount of dissolved oxygen in a stream decreases on being joined by the outflow from a pond, indicating the pollution of the stream by the sewage. The exposure of the effluent sludge and the receiving stream to sunlight over the twenty-day period may be responsible for the inactivation of microorganisms which in turn reduced the rate of utilization of dissolved oxygen in the effluent sludge and the receiving stream.

Nitrate is an essential nutrient required for microbial growth and metabolism. In this study, the concentration of nitrate in both effluent sludge and the receiving stream decreased steadily over the twenty-day period of exposure to sunlight. In the effluent sludge, the concentration of nitrate was higher than those in the receiving stream and this may be because of the high organic matter content of the sewage oxidation pond [15].

The concentration of phosphate in the effluent sludge demonstrated a similar trend with the concentration of nitrate in the effluent sludge by decreasing steadily over the twenty-day period of exposure to sunlight. In the receiving stream, the concentration of phosphate was below detection limit of one milligram per litre until the twentieth day when the concentration increased slightly. This may be because of the rapid velocity and constant dissolution and dilution of sewage in the flowing stream.

Chloride, in the form of chloride ion is one of the major inorganic anions that is abundant in sewage because sodium chloride is a common part of most diet and it goes through the digestive system without its form been altered [1]. The concentration of chloride in the receiving stream was higher than those in the effluent sludge during the study. This may be because of the accumulation of chloride ions in the stream as well as in the sediments in the stream that are constantly resuspended as a result of sewage flowing into the stream.

The presence of heavy metals such as iron, lead, magnesium and zinc in the effluent sludge and the receiving stream could have originated from the effluent source and could pose a significant risk to human health, especially when waters from the stream are used for human activities such as cooking, drinking, bathing, irrigation, and recreation [11]. Reduction in some heavy metals concentrations after 20 days of exposure to solar radiation could be as a result of bioconversion by microorganisms present in the effluent.

5. CONCLUSION

The findings from this study demonstrated that solar energy is useful in reducing nutrients from organic matter and heavy metals in effluent sludge from the sewage oxidation pond and the receiving stream. These findings suggest that the solar energy exposure to the chains of processes in sewage treatment will produce effluents with minimal content of nutrients from organic matter and heavy metals, and these will ultimately protect the receiving stream from contamination, thus contributing to human health protection.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Olutiola PO, Awojobi KO, Oyedeji O, Ayansina ADV, Cole OO. Relationship between density and chemical composition of a tropical sewage oxidation pond. African Journal of Environmental Science and Technology. 2010;4(9):595-602.
2. Dwivedi BK, Pandey GC. Physicochemical factors and algal diversity of two ponds in Faizabad. India Pollution Research. 2002; 21(3):361-370.
3. Pandey. Trends in eutrophication research and control. International Journal of Hydrological Processes. 2003;10(2):131-295.
4. Szymanski N, Patterson RA. Effective Microorganisms (EM) and wastewater systems. Proceedings of On-site Conference – Future Directions for On-site Systems: Best Management Practice; 2003.
5. Schulz K, Howe B. Uncertainty and sensitivity analysis of water transport modelling in a layered soil profile using fuzzy set theory. Journal of Hydroinformatics. 2003;1:127-138.
6. Ujang Z, Christensen CL, Milwertz L, Thomsen MH, Vollertsen J, Hvitved-Jacobson T. Performance Analysis of Wastewater Stabilization Ponds. 2002;3 (1):234.
7. Wurts WA. Sustenance aquaculture in the twenty – first century. Reviews in Fisheries Science. 2000;8(2):141-150.
8. Gulson BL, Sheehan A, Giblin AM, Chiaradia M, Conradt B. The efficiency of removal of lead and other elements from domestic drinking waters using a bench-top water filter system. Science of Total Environment. 1997;196:205-216.
9. Adigun BA. Water quality management in aquaculture and freshwater zooplankton production for use in fish hatcheries. National Institute for Freshwater Fisheries Research, New Bussa, Niger State. 2005; 26.
10. Watson C, Cichra CE. Department of fisheries and aquatic sciences, florida cooperatives extension services. Institute

of Food and Agriculture Sciences, University of Florida. First edition; June 1990, second edition; 2006.
11. Peretiemo-Clarke BO, Balogun MA, Akpojiyovwi O. A study of physicochemical characteristics of Ugborikoko/Okere stream as an index of pollution. African Journal of Biotechnology. 2009;8:6272-6276.
12. Viessman W, Hammer MJ. Water and pollution control (6th edition). Prentice Hall. 1998;13:978–979.
13. Hacioglu N, Dulger B. Monthly variation of some physicochemical and microbial parameters in Biga stream, Biga, Canakkale, Turkey. African Journal of Biotechnology. 2009;8:1927-1937.
14. APHA. Standard methods for the examination of water and wastewater (22nd ed.) APHA/AWWA/WEF: Washington DC, USA; 2012.
15. WHO. Nitrogen oxides. Environmental Health Criteria. 2ed No. 54. World Health Organisation, Geneva, Switzerland; 1997.

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