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Efficiency of oxidation ponds in wastewater treatment

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ABSTRACT: A research was conducted at Kauma oxidation ponds, a Sewage water treatment plant found in Lilongwe, Malawi with an aim of establishing the efficiency of these sewage treatment ponds in treating sewage wastewater. Water samples from the effluent discharging points in the maturation ponds were collected and analysed in the labouratory for, BOD, Coliform bacteria, Total Nitrogen (TN), Phosphorous and Chlorophyll-a. Other parameters like Temperature, DO, and pH were measured on site. It was found out that FCB, TP, TN, Chlorophyll a and BOD were $4.59x10^3$CFU, $1.94x10^3$µg/L, $1.78x10^3$µg/L, $2.68x10^3$µg/L and 10.6mg/L, way above the WHO guidelines for drinking, swimming and bathing waters for which uses is the Lilongwe river to which this effluent is discharged. The presence of FCB, BOD, P, chlorophyll-a, in large quantities indicates the inefficiency of the oxidation ponds. Furthermore, the presence of high concentration of chlorophyll-a indicated a heavy loading of the river with organic matter found in phytoplankton demanding a tertiary treatment to have a clean water discharged into the river system.

Key words: Sewage treatment, Oxidation ponds, Efficiency, Coliform bacteria, WHO guidelines

INTRODUCTION

Fresh water quality in Malawi is greatly affected by human activities, like agriculture, effluent discharge and refuses dumping. The contamination of these water resources could also be attributed to the poor sanitation facilities, frequent break down, overloading and scarcity of spare parts. One of the serious problems being faced world wide is the availability of fresh water and the most challenging issue is management of the resource, which should be done on a broader basis (DeREA, 1994). Any wastewater treatment plant is regarded as efficient if it meets the recommended microbiological and chemical guidelines at both a low cost and minimum maintenance and operational requirements (Arar, 1988).Wastewater treatment is the single most important way of ensuring that sewage waste is properly handled before finally being discharged into the environmental systems. There are a number of methods through which this can be carried out but by far, wastewater treatment through the use of waste stabilisation ponds (WSP), has been considered as the ideal way of improving effluent quality by means of natural processes and sewage is basically water containing waste matter, chemicals, inorganic solids and dry solids. Sewage is composed of dissolved and suspended material and its quality is mainly identified in terms of suspended solids, biochemical oxygen demand and ammonia content but typically, raw sewage is composed of 1-7% solids and 75% organic materials, whose main constituent is the nitrogen compounds among others, (Pickering and Owen, 1994. Mechanical or physical water treatment is the first process in water purification that involves the screening of sewage from the sewerage system. At this stage, all the large and heavier solid matter is removed from the sewage, which is then led to the grit chamber where there is settlement and sludge formation. All floating material is removed through a skimming process, which is the physical removal of floating substances from the sewage effluent. The primary water treatment process removes just about 30% of the organic wastes and 50% of suspended solids and bacteria (Miller, 1998).

The danger associated with this standard water treatment procedure is that, not all pollutant categories are removed. Some of these include organic chemicals, heavy metals, phosphates and

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nitrates (Botkin, 2003). Different organisations have specified their recommended threshold levels for various parameters these are also dependent on the use of the medium in which the effluent is to be discharged. For example the World Health Organisation (WHO), Irrigation and Water Department (I&WD), Water Resource Board (WRB) and Malawi Bureau of Standards (MBS) just to mention a few locally available boards. All of these have come up with guidelines on the recommended levels of different parameters that have to be met by the treatment facilities. When in excess, it becomes hazardous to human beings through drinking or consumption of aquatic products, thus fish (Mumba *et al.*, 1999). According to the United States Environmental Protection Agency (USEPA, 1993), the combined sewer overflows and septic systems which are point and non-point sources respectively, increases the availability of the following categories of pollutants in the water bodies; hardness, Biochemical Oxygen Demand, Salinity, pH, Bacteria, Ammonia, Turbidity, Total Dissolved Solids (TDS), Toxins and Suspended Solids. Kauma wastewater treatment plant is a type of sewage treatment plant that uses the stabilization ponds system of sewage treatment. In this case, no chemicals are integrated in the treatment of the waste which has proved to be effective where microbial contamination treatment is involved. The treatment process involves two sets of a series of stabilization ponds with varying functions, dimensions and detention times. Therefore this research conducted to determine the compliance of the discharged water from oxidation ponds to the set international guidelines.

MATERIALS & METHODS

This study was conducted at Kauma Sewage Treatment Plant consisting of oxidation ponds, refer figure 1. The treatment plant is made up of series of ponds hence oxidation ponds. This facility was constructed 1997. Potentially the plant has the capacity to cater for 61000m^3/day of liquid waste, but currently it is running at a capacity of 15600 m^3/day (approximately 25% of its capacity). Kauma sewage treatment plant is the largest in Malawi and third largest sewage treatment plant in the Southern Africa. This was among the many reasons for its selection as the study area. The basic argument was that since all the treatment plants are operated under the supervision of City Assemblies, the results obtained from this plant could be a reflection of the outcome from other facilities.

Samples were collected from the discharge points of both sets of the maturation ponds of the treatment plant. In addition to this, secondary data on the performance of the treatment plant was also collected from the employees and their weekly reports. Collected water samples were taken to the laboratory for laboratory analysis for concentration of Total Nitrogen (TN), Total Phosphorus (TP), Biological Oxygen Demand (BOD), Faecal Coliform Bacteria and Chlorophyll-a. Labouratory analyses were done in accordance to Wetzel and Likens, 2001; APHA, 2001 and Lind, 1991.Physico-chemical parameters, temperature, pH, salinity, Dissolved Oxygen, conductivity and Turbidity were measured on site.Microsoft Excel package was used to determine the mean, median and ranges for the results that were got from the analyses.

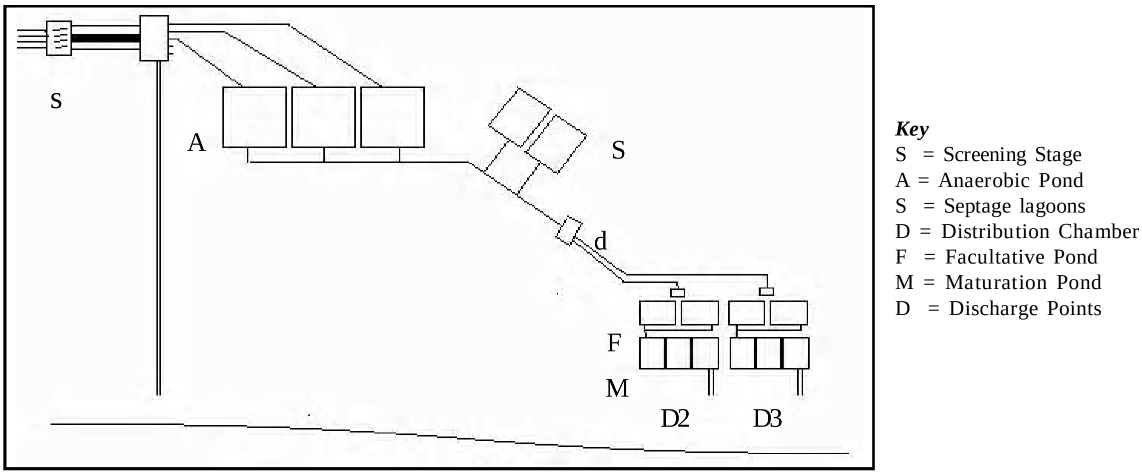

Fig.1. Sketch of Kauma Sewage Treatment plant (*Not drawn to scale*)

RESULTS & DISCUSSION

The physical chemical parameters were measured on sunny days at around 2pm. As shown in Table 1 below, Dissolved Oxygen is in the intermediate range and turbidity is high. However pH and temperature were within normal ranges. Surprisingly, salinity is higher than values normally found in inland waters Mean results are indicated in the Table 2. The values of all the parameters determined were above the guidelines provided by WHO.From the results that were found in this study, it has been discovered that some of the water quality variables were above the recommended WHO guidelines. Chlorophyll-a This is above the recommended guidelines for drinking and other domestic uses. High concentration of chlorophyll a in the effluent indicates that the system releases water with very high concentration of phytoplankton. Information from the employees indicated that phytoplankton is not harvested from the waters before it is released into the receiving river. High phytoplankton concentration impacts the river system to which this water is discharged in terms of oxygen demand, nutrient enrichment, light. It also renders the water not suitable for many domestic uses since the green colour; odour and turbidity that come with high concentration of algae become a nuisance.Dissolved oxygen was measured during sunny days in the afternoon. A high concentration of DO indicates that there is high photosynthesis that is releasing oxygen into the water. This result correlates very well with high concentration of chlorophyll *a* in the same effluents Nutrients could be from the sewage system or from birds that were always found in the maturation ponds eating algae and insects. However, high concentration of phosphorous indicates that the water is not completely treated and need further inactivation of phosphorous. If this high phosphorous is released into the river system, it will encourage primary production especially for cyanobacteria for which phosphorous is their limiting nutrient.Faecal Coliform Bacteria (FCB) can come from plants, soil or animals. However, this being measured in the sewage water, the waste water that come from homes of human being, the contributions of other sources such as plants, dogs, and soils to this concentration of coliform in this water is very insignificant. Therefore, this coliformbacterium is from water being polluted by human wastes including faeces.Worse morel, the concentrations are very high beyond the recommended guidelines by World Health Organisations (WHO) for waters to be used for drinking and other domestic purposes and there is no tertiary water treatment. This also shows incomplete treatment of the water. This poses a health hazard to the people who use the water from the river. This is because the probability of finding the dangerous and virulent bacterial, fungal and viral pathogens such as entamoeba histolyca, *salmonella*, *shigella*, *vibrio* is very high.BOD of 10 and above and Turbidity of 250 and above indicates that water has been polluted hence there is incomplete treatment of this sewage.BOD exerts pressure on oxygen demand by other organisms found in that aquatic ecosystem hence may lead to reduced survival chances of those organisms which can not adapt to low oxygen supply or /and high turbid waters. Environmentally this is adverse because there is loss of biodiversity

Table 1. Onsite measurements of physical chemical parameters

Description	Temperature ^oC	pH	Dissolved O_2 (*mg*/L)	Conductivity (*µs/cm*)	Turbidity *NTU*	Salinity *(%)*
Mean	27.05±	7.4	11.0	0.66	252.5	0.02
Range	21.5- 28.9	7.4 -7.6	9.0-12.0	0.61-0.74	244-267	0.02-0.03

Table 2. Results and guidelines for water quality for drinking and swimming from WHO

Parameter	water Use	WHO Guideline (Standards)	Analysed effluent	Remarks
BOD *(mg/L)*	General	?2-4	10.6	Above recommended value
Chlorophyll-a *(µg/L)*	General	30-30000	$4.68x10^3$	Above recommended value
Total Phosphorous *(µg/L)*	General	10-25	$1.94 x10^3$	Above recommended value
Total Nitrogen*(µg/L)*	General	300-750	$1.78 x10^3$	Above recommended value
FCB *(counts/L00ml)*	General	0	$4.59x10^4$	Above recommended value

FCB: Faecal Coliform Bacteria **BOD:** Biological Oxygen Demand which later affect the proper functioning of an ecosystem.As already indicated, the Lilongwe River is the receiver of the effluent from Kauma Sewage Treatment Plant. The river is used by the surrounding communities as a source of water for bathing, drinking and even agricultural practices. On the other hand the river inhabits a number of aquatic life and imbalance of water quality variables would affect the stability of the aquatic ecosystems in this rive.World Health Organization recommends 5 coliform colonies/counts per 100ml of water more especially when the water is for drinking by human beings. Unfortunately among the parameters that are beyond the recommended guidelines are the faecal coliform bacteria (FCB), which is a group of bacteria found in human and other animals' sewage. When water is for human consumption, faecal coliform test is highly advisable and as is the case with the Kauma Sewage Treatment Plant effluent tertiary treatment would be recommended.Secondary data collected from the employees and other literature give evidence that there are a number of problems that still surround the treatment plant which contribute in its inefficiency. It was found that none of the people directly responsible for daily monitoring of the treatment process is qualified for this and no one has ever been trained but does it on trial and error basis, the labouratory either has un-serviced equipment or does not have particular equipment for conducting some tests. In addition to this, there is inadequate number of workers such that there is no body to monitor at night to the extent that during rainy seasons there could be overflowing or flooding from the ponds which usually start at night and is only discovered during day.

CONCLUSION

Just like Kauma oxidation ponds, most oxidation ponds do not fully treat the water to standard hence discharge water with high concentration of BOD, Coliform bacteria, Total Phosphorous, Total Nitrogen and Turbidity. The concentrations of these substances do not comply with the guidelines of World Heath Organisation and therefore pollute the river ecosystem posing environmental and health threats to the river ecosystems and users of the water respectively
It is recommended that there must be close monitoring of the treatment processes, redesigning of treatment plants to include re-circulation of the untreated water or by providing a constructed wetland or tertiary treatment system which will ensure further treatment of the effluent before being discharged.Laboratories must be revamped in terms of equipment and the personnel to improve their efficiency and Oxidation ponds must be renovated every after a specified interval apart from the usual maintenance works.

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