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Original Article

Assessment of the efficacy and impacts of Agrochemical and Food Company Ltd's waste water treatment plant on the quality of water in the river Nyando, Kenya.

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Abstract

Water quality management is one of the most challenging issues as the industrialization; urbanization and human population continue to grow globally. Large quantities of unmanaged wastewater (WW) from the industries and various municipalities find their ways into the water bodies and can have adverse effects on both public and ecosystem health. Efforts to assess the levels of pollution in water bodies through water quality assessment are therefore needed in order to create awareness to the concerned authorities so that necessary corrective measures can be undertaken. In this work, water quality assessment survey was carried out along the river Nyando in relation to the WW discharged from Muhoroni Agrochemical and food company (ACFC) Ltd over a period running from October 2015 to August 2016. Samples were collected five times from the sampling points labeled 1-5 during the entire period of study. The samples were then analyzed for selected physico-chemical parameters using standard analytical methods. The results showed that there were variations in the values of physico-chemical parameters between the sampling points 4 and 5 located along the river. The study also showed that the entire WWTP was very efficient in COD and BOD_5 with removal efficiencies of 92.47% and 97.26% respectively.

Key words: - Water quality, wastewater, efficacy, physico-chemical parameters, removal efficiencies

1.0 Introduction

Water is a key ingredient in economic development of a nation and plays an important role in every aspect of human life and the ecosystem in general. The demand of this resource globally is increasing alarmingly due to the rapid increase in human population, industrialization, rising living standards and expansion in agriculture [1]. On the other hand the level of waste generation on accounts of the rapid industrialization and population increase is on the rise [2]. This increase, however, has not been accompanied by an equivalent increase in the relevant waste management strategies. This implies that the propensity of unsafe disposal of waste is high leading pollution of the available fresh water bodies.

Various anthropogenic activities going on around the catchment areas of fresh water bodies also lead to water pollution rendering them unfit for various uses [3-8]. This results into a reduction in fresh water availability. In Kenya, the annual per capita water availability has been declining over the years to its current value of around 359 m3 and is further expected to drop to about 250m3 in 2030 [9]. Water scarcity is thus an impending disaster which threatens the lives of flora and fauna [10, 11].

In response to this, various authorities have been established with the fundamental goal and purpose of conserving, managing and protecting water resources. This saw the establishment of the National Water Quality Management Strategy (NWQMS) in Kenya by the Ministry of Water and Irrigation (MWI), following the enactment of the Water Act in 2002 [12]. The implementation of NWQMS was mandated to Water Resources Management Authority (WRMA). WRMA and the National Environmental Management Authority (NEMA) have come up with guidelines to ensure water safety. Water quality standards such as the effluent discharge standards as well as the standards for drinking water have therefore been established to ensure water safety [13]. The quality of water is identified in terms of its physical, chemical and biological

parameters such as the Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), PH, temperature, conductivity and turbidity [14].

In Kenya, there are many agro-based industries distributed throughout the country that generate large quantities of WW during their manufacturing processes. These wastes are treated in Wastewater Treatment Plants (WWTPs) using various methods before they are discharged into the nearby rivers or streams. If the level of treatment is not up to the required standards, the WW can cause serious water pollution. Various research reports on water quality deterioration in Kenyan rivers have mainly been attributed to domestic wastes, industrial wastes, surface runoff and agricultural chemicals [15-19].

A Study carried out by Kithiia and Mutua [20] on the effect of land use on water quality also revealed the degradation trends in water quality within the river systems that is caused by increase in the amounts of sediments. The recent studies on the river water quality have also revealed that the degradation of this resource is mainly due to the increasing anthropogenic activities [21]. The poor rural dwellers are the ones who will bear the brunt of the water pollution menace if necessary measures are not taken since they use the water directly from the rivers without any kind of treatment.

In this paper, an analysis of the Agrochemical and Food Company (ACFC) Ltd's WW and the effects they have on the receiving river Nyando is presented. The study involved the measurement and determination of the water quality parameters such as temperature, pH, EC, TSS, TDS, DO, BOD and COD along the WWTP and in the upstream and downstream sections of the river with reference to the industry's effluent discharge point. The efficacy of the entire WWTP was also evaluated based on the parameter removal efficiencies.

2.0 Research Methodology

In this research, the following procedure was used to achieve the desired research objectives.

2.1 Sampling and data collection

The data collection from the sampling points was carried out from the month of October 2015 to August 2016 which encompassed a short dry season and long wet season. Sampling was conducted five times in total during the entire period of study so that the temporal variation of the water quality could be noted. Samples were taken at three points (1-3) in ACFC Ltd's WWTP and two points (4 & 5) along the river Nyando as follows:

(i) Factory outlet (Point 1)
(ii) Anaerobic digester outlet (Point 2)
(iii) Effluent discharge point into the river (Point 3)
(iv) Upstream about 100m above the discharge point to the river (Point 4)
(v) Downstream about 100m below the discharge point to the river (Point 5)

2.2 Materials and Methodology

Temperature, DO, PH, TDS, turbidity and electrical conductivity were measured insitu by use of thermometer, dissolved oxygen meter, Ph meter, TDS meter, turbidimeter and conductivity meter respectively. Laboratory analysis was carried out at the water laboratory in Moi University to determine the parameters such as TSS, COD and BOD5 as per the APHA standard methods [22]. All through the study, samples were collected and taken to the laboratory within four hours of sampling. Three replicates of each sample were separately subjected to tests for BOD5, COD and TSS loading. The average values for each of the measured parameters along the sampling points were obtained.

3.0 Results and discussion

3.1 Average values of the parameters

The WW at sampling point 1 was characterized by a brown colour, high average influent BOD5, COD, TDS, TSS, turbidity and temperature of around 1606.17 mg/l**,** 88752.23 mg/l, 6712.1 mg/l, 6018.75 mg/l, 118 NTU and 37.94 0C. The values of PH, electrical conductivity and DO were very low each averaging about 4.2, 19.6 ms/cm and 1.78 mg/l respectively.

At the sampling point 3; after going through the secondary aeration tank and a series of four stabilization ponds; the PH increased to 8.58 while the concentrations of BOD5, COD, TSS and TDS further reduced to 332.67 mg/l, 6686 mg/l, 2436.25 mg/l and 3482.6 mg/l respectively. This corresponds to a further reduction in the concentrations At point 2; after passing through the anaerobic digester, where both the organic and inorganic matter are anaerobically digested; the PH and electrical conductivity each increased to an average value of 8.12 and 22.6 ms/cm respectively while the concentrations of BOD5, COD, TDS, TSS and temperature changed to 958.61 mg/l, 22488.9 mg/l, 2594.6 mg/l, 9050 mg/l and 33.66oC. Thus the BOD5, COD and TDS at this point are reduced by 40.32%, 74.66% and 61.34% respectively while TSS value increases by 275.67%. The increase in the value of the TSS is due to the excess sludge that is generated during anaerobic digestion of organic and inorganic materials in the biomethanation tank.

There is a further reduction of BOD5, COD and TSS by 72.72%, 70.27% and 92.98% respectively between the sampling points 2 and 3. The concentration of TDS, however, increased by 34.22% between these points. The achieved values of the removal efficiencies may deviate from the expected ones since the secondary aeration tank was under maintenance and some stabilization ponds were under de-sludging during the study period. The entire WWTP; from point 1 to point 3; achieved BOD5, COD, TSS and TDS removal efficiencies of 97.26%, 92.47%, 73.62% and 48.11% respectively. The comparison of the removal efficiencies of TSS, TDS, COD and BOD5 at point 2, between point 2 and point 3 and for the entire WWTP is shown in figure 1.

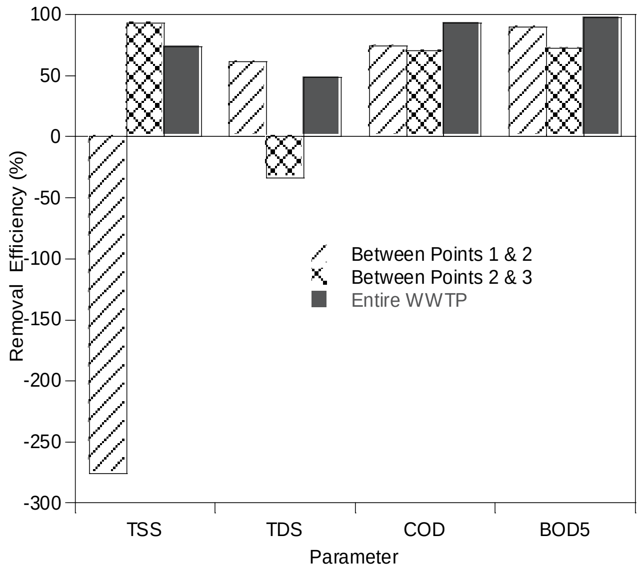

Figure 1: Parameter removal efficiencies

3.2 Effect on the receiving water

The WW discharged into River Nyando from ACFC Ltd has varied impacts on the physico-chemical properties of the river water depending on the prevailing weather conditions. To identify the impacts of the industrial WW on the water quality, the values of the parameters measured at sampling point 4 were taken as the reference values. The measured values of TSS, TDS, COD, BOD5 and turbidity were higher at point 5 compared to those at point 4. This shows that the effluents from the ACFC Ltd introduce some organic and solid pollutants into the river. The variation of TSS, TDS, COD, BOD5 and turbidity between point 4 and point 5 is shown in figure 2.

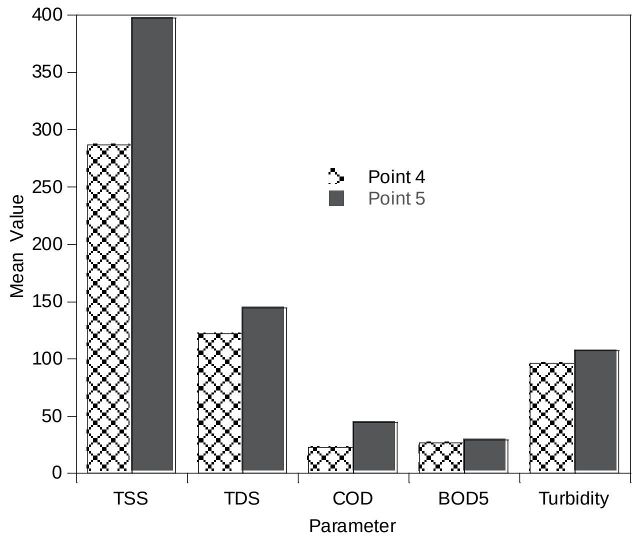

Figure 2: Parameter variation between points 4 and 5

The variations of PH, temperature, DO and electrical conductivity between points 4 and 5 was not so much significant as seen in figure 3. The mean values of temperature and electrical conductivity were slightly higher at point 5 than those at point 4. However, the values of PH and DO were consistently lower at point 5 than at point 4. The discharge of the industrial between point 4 and point 5

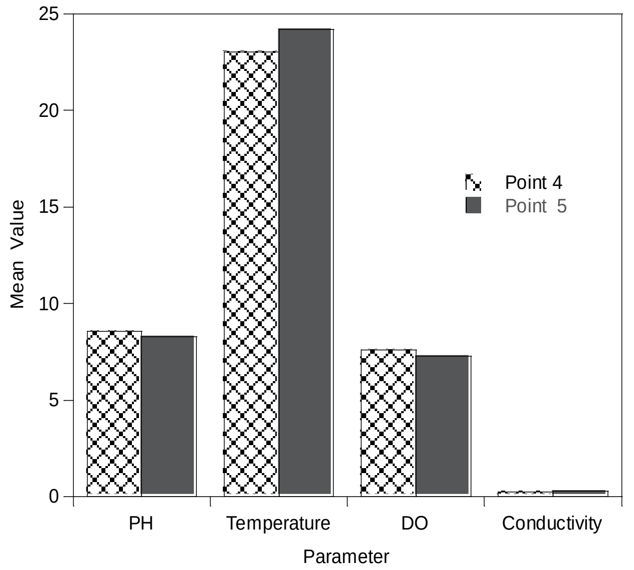

Figure 3: Variation of PH, Temperature, DO and conductivity between points 4 and 5

caused the observed increase in temperature and electrical conductivity. The low values of DO at point 5 could be attributed to the decomposition of organic substances from the effluents discharged from ACFC Ltd. The observed decrease in PH value at point 5 was an anomalous behavior given that its values at point 3 and 4 were higher. This implies that there could be some acidic substances that get into the river between points 4 and 5.

The variation in the nutrient element concentration between points 4 and 5 was also examined and the results are displayed in figure 4. It was observed that the levels of nitrites (NO_2^-) and nitrates (NO_3^-) were slightly higher at point 4 than at point 5. This could be attributed to various non-point sources of pollution along the river catchment area above the ACFC Ltd's discharge point. The values of ammonia (NH_3) and phosphates (PO_4^-) were slightly higher at point 5 compared to those observed at point 4 confirming the contribution of pollution from the industrial effluents.

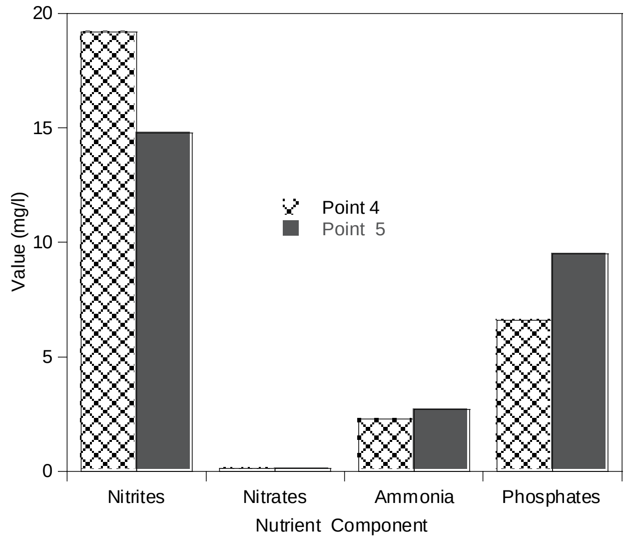

Figure 4: Nutrient element concentration at points 4 and 5

It was further observed that there was seasonal variation in the concentration of most parameters in the river, being higher in the dry season than in the wet season. The reddish brown colour of the effluent was seen in the downstream section of the river during the dry season. Furthermore, the odor of the effluent could be detected in the water at the downstream during the dry season. All these observations can possibly be attributed to the reduction in the volume of water in the river which reduces its dilution ability.

3.3 Parameter variation along the sampling points

The variations of the measured parameters along the sampling points are displayed in figure 5-10.

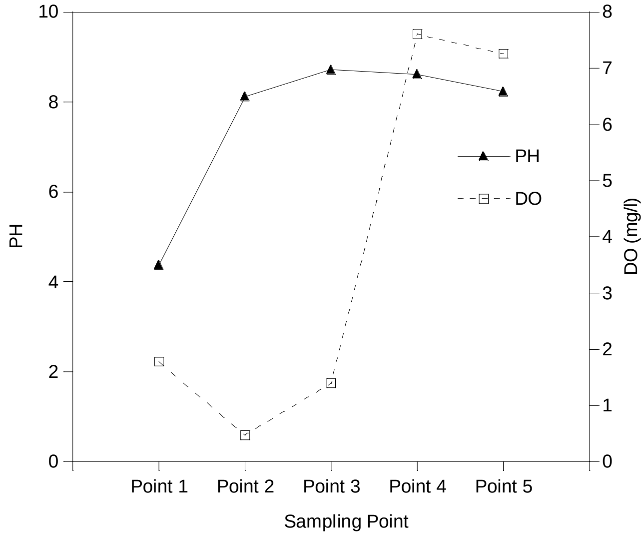

Figure 4: Variation of pH and D.O along the sampling points

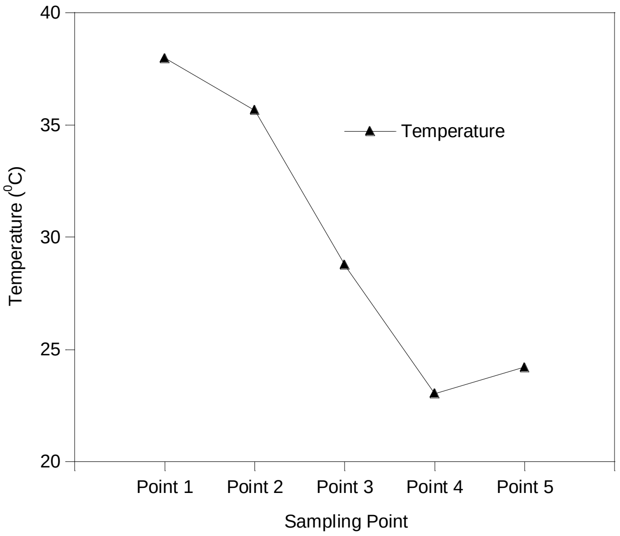

Figure 6: Temperature variation along the sampling points

4.0 Conclusion and Recommendation

The water pollution along the river Nyando is not caused by the WW discharge from ACFC Ltd only. There are other non-point sources of pollution in the upper section of the river as indicated by high values of some parameters at sampling point 4. The values of TSS and PH deviated from the NEMA standards even at sampling point 4. The observed seasonal variation in the values of water quality parameters call for the real-time monitoring of water

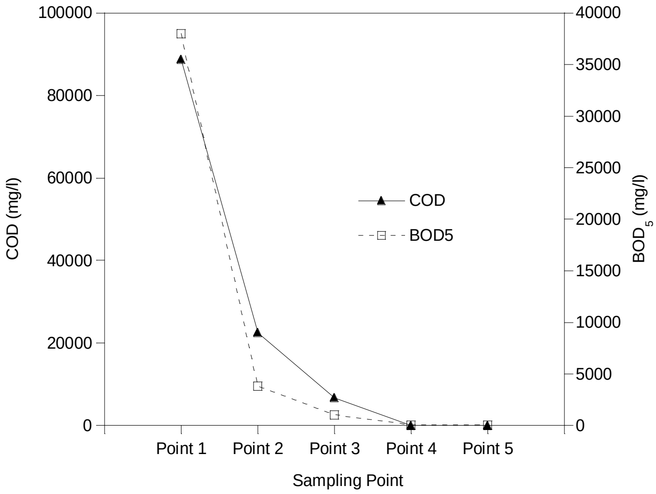

Figure 5: COD and BOD_5 variation along the sampling the points

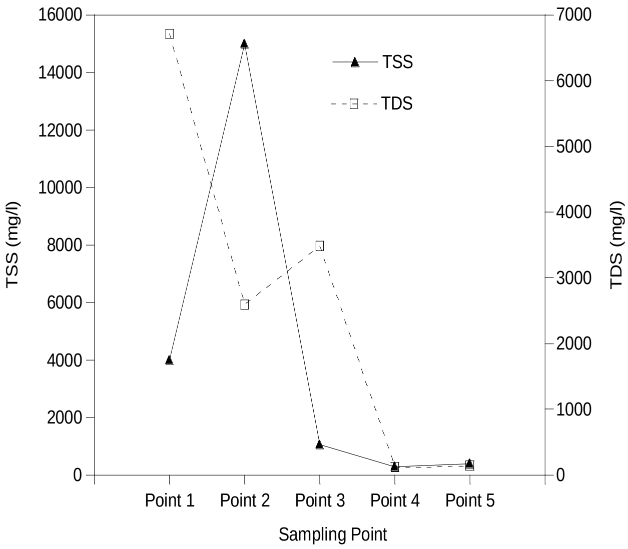

Figure 8: TSS and TDS variation along the sampling point

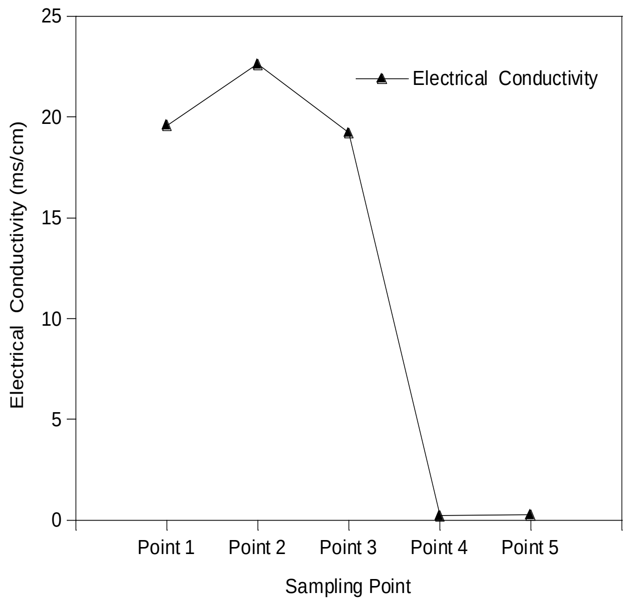

Figure 6: variation in electrical conductivity along the sampling points

quality and immediate transfer of data to the concerned authorities. Further research needs to be carried out on the possibility of using wireless sensor technology in water quality assessment. Further studies are also needed to be carried out to examine the anomalous behavior in PH.

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