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Assessment of Selected Parameters for Industrial Effluents from Some Industrial Sites in Nairobi, Kenya

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Abstract The discharge of industrial effluents into the environment poses a threat to human health and is of environmental concern to both plants and animals. Over the last several years there has been a great deal of pollution caused by sewerage treatment works and industrial plants discharging effluents into the environment. This has been caused to a large extent by rapid population increase in the cities and towns, which has led to a strain on the plants' capacities. The industrial effluents from selected industries in Nairobi's Industrial area, Kenya were analyzed to determine the physico-chemical properties which were then compared to the guidelines of the National Environment Management Authority (NEMA). The effluents were collected from four different industrial sites namely General Plastics Industries Ltd., Bhachu Industries Ltd., Chloride Industries and Sameer Africa. pH, color, temperature, chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS) and oil and grease were analyzed using standard analytical methods. The results in range form for the four sites were as follows: pH 7.4- 8.7; colour 26-44 Hazen units; temperature 20.5- 27.7 ^{0}C; COD 22.22-96.30 mg/L; TSS 25.00-26.37 mg/L; TDS 1080.7-1225.3 mg/L; Oil and Grease 5.71-12.52 mg/L. pH, colour, and oil and grease for effluent outside Sameer Industries were above NEMA guideline values for discharge into the environment. General Plastic Industries had colour, total dissolved solids and oil and grease all above NEMA guideline values. Colour, total dissolved solids and chemical oxygen demand outside Bhachu Industries were also higher. At Chloride Industries only colour was above the guideline value. There is therefore need to use appropriate treatment methods to lower these values.

Keywords Industrial Effluent, Physico-chemcical Parameters, Industrial Sites, NEMA Standards

1. Introduction

The rapid industrial development has led to the increasing release of industrial effluents that has raised public health and environmental concerns. Environmental pollution in various forms is a threat to the wellbeing of human kind and to the prosperity of the world. Exposure to the pollutants at sufficiently high concentrations can cause a variety of health problems [1] The intensity of environmental pollutants from industrial wastes has attracted the attention of scientific and administrative authorities all over the world [2]. A pollutant is a substance that occurs in the environment as a result of anthropogenic activities and which has a harmful effect on the environment [3]. Pollution is a major environmental issue in the world due to its adverse effect on living organism.

Discharge standards are important management tools which ensure the protection of the receiving systems. It is for this reason that the assessment of parameters for monitoring industrial effluents is essential to environmental quality. The main sources of industrial effluents are chemical manufacturing and processing industries. Effluents like oil and grease could come from a variety of sources like crude oil production, oil refiners, petroleum products, metal processing, lubricants, car washings and restaurants [4]. The nature of the effluents depends on the types of raw materials used in the industries and the efficiency of the industrial processes. The analysis of the effluents is important in environmental monitoring and the potential health effects of the byproducts [5]. As the Nations develop their industrial activities, production and use of chemicals rise in response to the standards of living and consequent increase in life expectancy [6]. It is important for the industries to treat the effluents before their release to the environment to sustain the environmental standards. The chemicals and related industries in Kenya are, to a large extent dominated by a very large importation of chemicals used in the various industrial processes. The industrial effluents from various plants situated in Nairobi's industrial area drain their effluents into Nairobi River. It has been reported that industries discharge untreated effluents into public sewer which eventually enters the river [7]. The pollution witnessed in Nairobi River (Fig. 1) could be attributed to the industrial effluents discharged into the environment by industrial plants in the neighborhood.

Figure 1. Polluted Nairobi River. Source [8]

This has raised a lot of concern from the public as well as regulators regarding the toxicological effects on domestic water as well as the safety of aquatic organisms whose natural habitat is affected by the effluents. Water pollution occurs when pollutants are discharged into water bodies without proper treatment. Some of these pollutants are also deposited on the land thereby rendering agriculture harmful. In view of the potential health problems arising from such effluents, a study was conducted to assess physicochemical parameters of industrial effluents from selected industrial sites in Nairobi's industrial area.

2. Materials and Methods

2.1. Collection of Samples and Sampling Techniques

Industrial effluents were collected from four discharge sites on the outside of General Plastics Ltd. , Bhachu Industries, Chloride Industries Ltd. and Sameer Africa located along Enterprise Road in the industrial area in Nairobi. From each site three points were sampled. The sampling sites are shown in Fig 2.

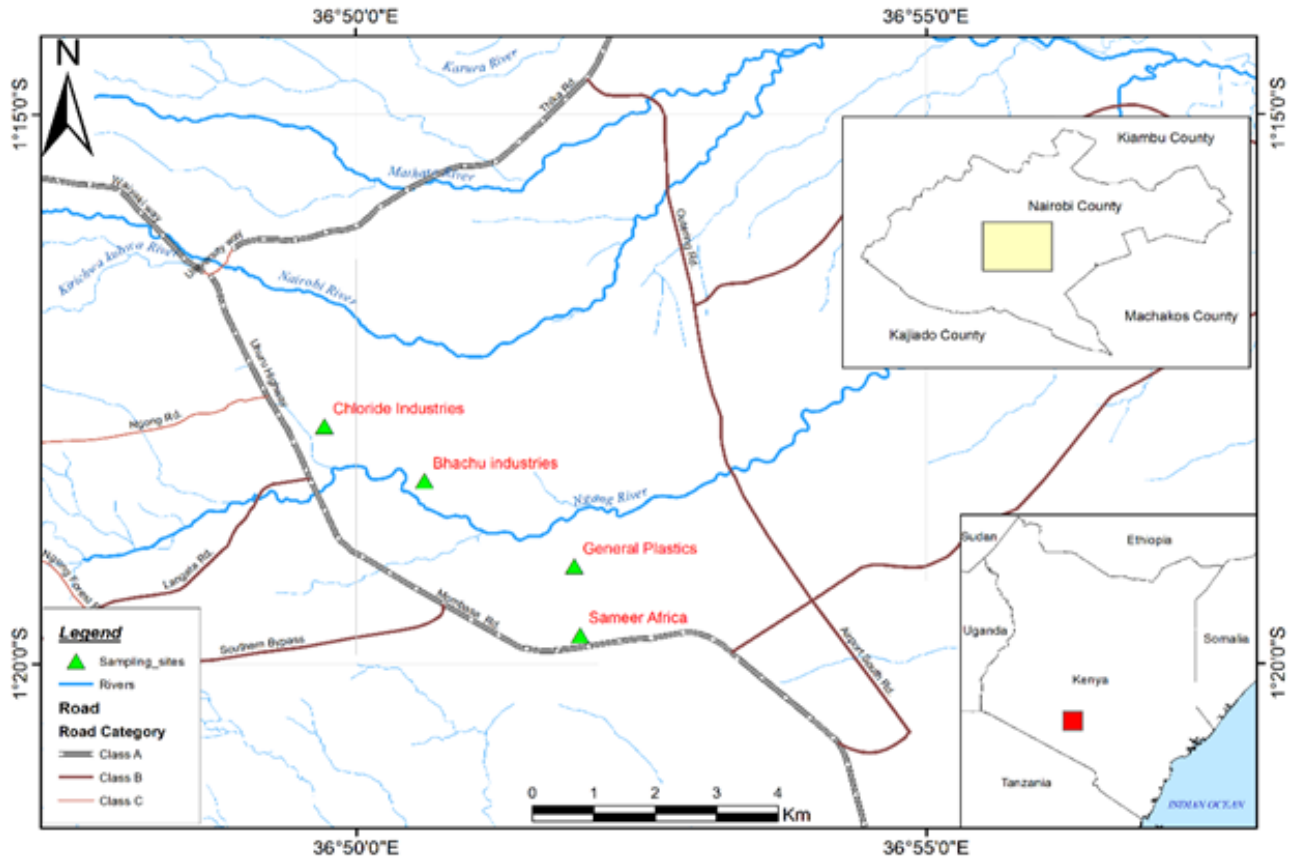

Figure 2. Map of the four sampling sites in industrial area, Nairobi (Kenya)

Sameer Africa is a complex having a number of service industries with the main industry being tyre manufacture. Bhachu Industries is involved with body building of various types of vehicles. Chloride Industries and General Plastics manufacture batteries and plastics respectively. The coordinates of the four sampling sites are given in Table 1.

Table1. The coordinates of the sampling sites at the industrial area in Nairobi

Site	Longitude	Latitude	Altitude
General Plastics Ltd.	E036^0 52.222	S01^0 19.649	1645 M
Bhachu Industries	E036^0 52.224	S01^0 19.387	1646 M
Chloride Industries Ltd.	E036^0 52.167	S01^0 19.329	1646
Sameer Industries	E06^0 52.091	E036^0 52.091	1637

Septic sampling technique was used to collect samples to avoid contamination by microorganism as described by [9]. The plastic bottles were first rinsed with detergent and then washed with distilled water. The effluent samples were collected directly from the discharge points into one litre sterile bottles by lowering the bottle into open source until the bottle was filled with the effluent. The samples were immediately taken to the laboratory and stored at 4^0C $\pm 2^0$C for subsequent analysis within a period of 24 to 48 hours [9]. The samples were collected during the month of November, 2013 during the dry season.

2.2. Determination of Parameters

2.2.1. Determination of effluent temperature

The collected effluents were allowed to equilibrate in sample bottles and the temperature determined using a mercury thermometer. The temperatures were then recorded for each effluent sample at the sampling site.

2.2.2 Determination of the effluent pH

A pH meter (model pH S-2C) was used to determine the pH of the effluent samples from each site then the mean was taken to represent the pH of the effluent. The procedure was as described by Ademoroti [10]. The pH expresses the intensity of acidic or alkaline condition of a solution, which must be controlled in wastewater within a range favorable to particular organisms and chemical processes involved in biodegradation and for coagulation of effluents, precipitation of heavy metals, draining of the settled sludge and oxidation of ions of certain toxins [11].

2.2.3. Determination of colour

Visual comparison method was used in which colour standards were prepared from stock solution. The colour of each sample was observed and compared with that of the standard. The colour of the effluents was calculated and recorded in colour units.

Calculation of colour units

For the diluted sample, colour was calculated as follows:

$$Colour\ units = \frac{a-50}{b} \tag{2.1}$$

where a is the estimated colour of diluted sample, and b is the volume in ml of sample in the 50 ml diluted sample.

2.2.4. Determination of Total Dissolved Solids (TDS)

Gravimetric method as described by Ademoroti [10] was used in the determination of Total Dissolved Solids.

Calculation of TDS

$$TDS\ in\ mg/l = \frac{(w-y)\ \times 1000}{Sample\ volume\ (ml)} \tag{2.2}$$

where w is the weight of dried residue and container and y is the weight of container in grams.

2.2.5. Determination of Total Suspended Solids (TSS)

Gravimetric method was used to determine the suspended solids.

Calculation of Total Suspended Solids

$$TSS\ in\ mg\ /l = \frac{(z-m)\ \times 1000}{Sample\ volume\ (ml)} \tag{2.3}$$

where z is the weight of filter paper and dried residue in g and m is the weight of filter paper in g.

2.2.6. Determination of Chemical Oxygen Demand (COD)

Chemical Oxygen Demand indicates the strength of polluting water, in measuring the amount of oxygen which will be required to oxidize the organic matter but is not limited to the bacterial activities. Open reflux method as described by Ademoroti [10] was used to determine COD.

Calculation of COD

$$COD\ in\ mg/L = \frac{(s-v)\ \times 1000\times M}{Sample\ volume\ (ml)} \tag{2.4}$$

where s is the volume of ferrous ammonium sulphate ((FAS) $Fe(NH_4)_2(SO_4)_2$) solution used as blank in ml, v is the amount of FAS in ml used for the sample and M is the molarity of FAS.

2.2.7. Determination of Oil and Grease

Soxhlet extraction method was used to determine oil and grease in the sample according to method described in APHA.[12] Since interferences may occur, it is important to note that this method is entirely empirical and hence duplicate results can only be obtained by strictly adhering to experimental conditions.

Calculation of oil and grease in the sample

$$Oil\ and\ grease\ in\ mg/L = \frac{W_{ext}(mg)}{V_s(l)} \tag{2.5}$$

where W_{ext} is the weight of extractable material (mg) and V_s is volume of the sample in litres.

Table 2. Physico-chemical parameters of the industrial effluent analyzed for the sites

Parameter	Sites				NEMA Standards*
	General Plastics	Bhachu Industries	Chloride Industries	Sameer Africa	
Temperature ^{0}C	22.7±1.2	22.0±1.3	26.0±1.4	20.5±1.1	20-35
pH	7.5±0.6	7.4±0.9	7.2±0.2	8.7±0.3	6.5– 8.5
Colour (Hazen units)	44±2.1	41±1.9	32±1.6	25±1.0	< 15
Total dissolved solids (mg/L)	1201.0±10.2	1225.3±9.6	1080.7±10.1	1084.7±6.6	1200
Total suspended solids (mg/L)	26.19±0.40	25.00±0.60	25.17±1.22	26..37±1.23	30
Chemical oxygen demand (mg/L)	44.45±1.50	96.30±2.30	29.63±2.61	22.22±1.40	50
Oil and Grease (mg/L)	12.52±1.11	5.72±0.31	9.68±1.92	12.26±1.50	10

3. Results and Discussion

In Kenya, the National Environment Management Authority (NEMA) has standards for effluent or wastewater before it is discharged into water or land. The maximum permissible levels are provided in the National Environment Standards for discharge of effluent into water or on land under the regulations S.I. N0. 5/1999. The values for the parameters of the industrial effluents determined in this study are presented in Table 2.

From the results in Table 2, pH (Sameer Africa), colour (General Plastics, Bhachu Industries, Chloride Industries, Sameer Africa), TDS (General Plastics, Bhachu Industries), COD (Bhachu Industries) and oil and grease (General Plastics, Sameer Africa) were all above the maximum allowable level as given by NEMA. Colour was high due to the types of industries in this area that generated dyes, oil and grease, batteries by-products and tyre wastes. Total dissolved solids were also elevated due to the large amount of inorganic paint waste discharged into the sewerage system.

4. Conclusions

Colour, pH, and oil and grease for the site outside Sameer Industries were above NEMA guideline values for discharge into the environment. Outside General Plastic Industries colour, total dissolved solids and oil and grease were all above NEMA guideline values. Colour, total dissolved solids and chemical oxygen demand outside Bhachu Industries were also higher. Outside Chloride Industries only colour was above the guideline value. The regulatory agency, NEMA should therefore put in place appropriate measures to ensure that industries releasing effluents into the environment conform to the standards.

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