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Physicochemical Parameters and Heavy Metals Analysis of Wastewater from Kakuri Drain in Makera/Kakuri Industrial Layout, Kaduna, Nigeria

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Abstract
The Kakuri drain carries wastewater from Kakuri/Makera industrial layout and environ into river Kaduna. Samples were collected from points/stations 200m apart and labeled as points C, D, E and F, for a period of six months. Physico-chemical studies shows level of determined parameters to be within safe limits as recommended by WHO. Temperature reading showed an average of +_25.5^{0}C in water as against 26.5^{0}C on surface water. The Dissolved oxygen (DO) in the water was recorded as _+1.77mg/l, while the BOD had a mean of _+9.93mg/l .The level of heavy metals in the wastewater showed chromium with levels higher than the approved values recommended by WHO. Level of metals analyzed were as follows; chromium _+ 0.05853ppm. Lead _+0.03058ppm, copper _+1.08505ppm and _+0.45203ppm for zinc. Mean concentration of TDS for the various sampling points (C,ED,E and F) showed significant difference (at 5% significant level), with the highest value of _+488.83mg/l in September and the lowest value of _+415.33mg/l recorded in April. Values may appear low, but the effect of bioaccumulation in crops raised by using such water for irrigation and subsequently consumed by man cannot be underestimated.

Introduction

Kaduna, is a cosmopolitan town in the Northern part Nigeria where farming is a past time. Farming takes place both during the Wet season as well as the Dry season. Municipal wastewater is often used in most cities in Nigeria for dry season's vegetables production (Sarkinnoma et al 2013) and Kaduna is no exception. In the dry season, farmers rely on the streams, ponds, rivers and drains, which are actually tributaries of a river as in the case of Kakuri drain which empties into river Kaduna. There are about 53 of such tributaries or drains that all empty their content into river Kaduna. The Kakuri drain carries effluents from several industries within the Makera/Kakuri axis. Industries here include several Textiles (Arewa Textile, Nortex etc), Super Phosphate Fertilizer company, DICON (Defence Industries Corporation Of Nigeria), PAN (Peugeot Assembly of Nigeria) among host of others. Waste from these industries is dumped into these drains and carried away into river Kaduna. Waste from the domestic front also ends up in the drain, as the Makera/Kakuri layout is a densely populated area. Today water sources are increasingly becoming polluted from both point and non point sources due to agriculture, urbanization, and industrialization which contribute to organic, inorganic and aesthetic pollution of water (Morrison et al, 2001).

Heavy metals and other toxic substances dumped into the drain from these industries pollute the water furthermore, hence making it hazardous to health (Aken 2008). Important toxic metal pollutants like cadmium, lead, and zinc enter water bodies through industrial wastewater treatment plants (Denise et al 1989; Ajmal et al 1998). The toxic substances and the heavy metals also end up in the soil at the banks of the drain or tributaries, as farmers irrigate their crops with water from the drain. Gradually and over time, these heavy metals and other toxic substances accumulate and crops raised on such soils at the bank, take up the heavy metals and accumulate them in their cells (Kim et al 2003). Such vegetable crops eaten, usually raw, my man pose great health hazard to the community (Kemdirim and Matazu,(2003). Lead (Pb) content in water and soil is closely linked to leaded gasoline, lead based paints, sewage sludge as well as industrial wastes (Zakrzewski 1991). The accumulated heavy metals in the soil also pose a threat to groundwater sources, as they tend to leach into underground water level.

Wastewater from the domestic front brings in other minerals as phosphates, dissolved solids, suspended solids, nitrogen (N),chloride, grease, phosphorus, antibiotic compounds, etc. which greatly alter the natural constituent of the stream and affects the living fauna and flora in the water (FAO,2011).High concentration of these waste have adverse effect on the physicochemical properties of the receiving water which consequently affects the biota in such water bodies. Also crops irrigated with such wastewater are affected. Maize and Tsunga grown with sewage wastewater irrigation were observed to be heavily contaminated with Cd, Cu, Pb and Zn (Muchuwetis et al., 2006). Significantly higher heavy-metals accumulation in spinach than okra fruit has been observed (Lone et al., 2003). In general however, heavy-metal accumulation and absorption by plants grown in contaminated environment followed the order of magnitude of greater availability in the surrounding medium

(Kim et al., 2003).

Materials and Methods

Kaduna town lies at an altitude of 10. 20 N and longitude 7.24 E and is the capital of Kaduna state, in Northern Nigeria. The town has a population of about 2 million inhabitants. The large population and human activity has led to the release of large amounts of waste discharged into the environment. Kaduna has an industrial layout in the southern part- the Makera/ Kakuri industrial layout. Many industries are located in the layout and is densely populated. Some of the industries include, Superphosphate Fertilizer company, Turner's Asbestos Products (TAP) that produce roofing sheets, Breweries, Textile companies and the military factory, DICON, Defence Industries corporation of Nigeria, which has an Electroplating unit and a treatment plant. All these and the settlement around it , generate a lot of waste which ends up in the drains and subsequently into river Kaduna (Emere 1996).

Wastewater samples from the Kakuri drain were collected from four designated points along the drain before it enters into river Kaduna. Samples were collected from the 4 points (C D E & F) according to procedure (APHA 1991). Point A was the raw waste from the treatment plant of the Electroplating Unit at DICON, while B was the treated waste discharged from the factory. Point C therefore, is the treated waste discharged into the Kakuri drain. Point D was the sampling point along the drain after the Super Phosphate Fertilizer company. Point E was the point of discharge into River Kaduna. Point F serves as control and was designated 200m before the discharge point, that is Point C. It is free of waste from the DICON, suspected to be an additional source of heavy metal and other contaminants in the drain.

Wastewater samples were collected in black polythene bags and sent to the laboratory for analysis. Physicochemical parameters measured here included pH, Temperature, EC, DO, TDS BOD, COD etc. Heavy metal content in wastewater and soil was also assessed. The following metals were considered for the analysis; Lead, Chromium, Arsenic, Copper, Zinc, Cobalt and Cadmium. Metals were analyzed using the AAS machine (Atomic Absorption Spectrometry- Young Lia AAS 8019 model).

The SPADNS method was employed for the estimation of total nitrogen and fluoride in the wastewater from the Makera Drain. Estimation of Sodium and Potassium content in the wastewater was done by employing the flame photometric method at 589nm.The perchloric Acid digestion method was employed for the determination of Phosphate and Sulphate, while the Calcamagite method was employed to determine total Calcium content in the sampled wastewater.

Results

Readings of all parameters were tabulated and for further clarity were presented in graphical forms in some cases.

TABLE 1 -MEAN COMPARISON FOR PHYSICOCHEMICAL PARAMETERS AT SELECTED MONTHS-

	Feb	March	April	May	June	July	August	Sept.	Means
pH	7.013	6.112	6.533	6.475	6.535	6.552	5.937	7.013	6.512[a]
EC	11.473	16.337	13.645	10917	13.497	15.153	11.353	14.697	13.384[a]
TDS	448.000	465.833	415.333	466.667	431.833	468.500	459.500	488.833	455.562
DO	1.463	2.712	2.188	2.793	3.060	1.127	1.125	1.262	1.966[a]
COD	14.532	16.803	17.188	19.112	18.080	12.325	12.917	12.917	15.484[a]
BOD	19.838	11.180	8.928	11.573	11.365	5.628	6.233	6.183	8.991a
Temp. (AW)	24.850	27.008	26.273	24.437	25.680	30.330	26.585	27.633	26.600[a]
Temp (Water)	24.300	26.363	24.953	23.615	25.275	26.723	26.225	26.967	25.553[a]
Means	67.809[b]	71.544[b]	64.381[b]	70.699[b]	66.916[b]	70.792[b]	68.734[b]	73.188[b]	69.258[b]

Note: Figures followed by the same letters are not statistically significant at 5% level according to the Least significant Difference (LSD) test.

TABLE 2 -MEAN COMPARISON FOR HEAVY METALS SALTS AT SELECTED STATIONS.

	A	B	C	D	E	F	Means
Chromium	156.90	25.286	0.1753	0.0273	0.0211	0.0098	31.726
Lead	1.0236	0.4075	0.0318	0.0334	0.0291	0.0280	0.264[a]
Cadmium	2.8146	0.6103	0.0640	0.0410	0.0340	0.0179	0.597[a]
Copper	17.733	4.545	1.4994	0.9496	0.9984	0.8928	4.499[a]
Zinc	6.5286	2.8538	0.4324	0.4665	0.4448	0.4644	1.865[a]
Arsenic	13.163	-0.4934	0.0319	0.0135	0.0098	0.0106	2.368[a]
Means	33.028	5.535[b]	0.348[b]	0.255[b]	0.267[b]	0.269[b]	6.886

Note: Figures followed by the same letters are not statistically significant at 5% level according to the Least significant Difference (LSD) test.

TABLE 3- Heavy Metal Salts Concentration at Selected Months

	Feb	March	April	May	June	July	August	Sept.	Means
Chromium	25.295	28.256	24.080	28.350	21.052	38.446	49.662	43.755	31.725
Lead	0.2317	0.2267	0.4360	0.3683	0.3650	0.0468	0.1673	0.2325	0.2638
Calcium chloride	0.0817	0.0933	1.4277	1.4133	1.6715	0.0480	-0.0193	0.0595	0.5970
Copper	5.1533	5.0967	4.1150	4.3267	3.9912	8.9448	2.0982	1.8663	4.4990
Zinc	1.9703	2.3983	2.0612	1.5283	1.5533	1.6448	1.7617	2.0025	1.8615
Arsenic	2.3660	2.1633	1.7933	2.0268	4.3850	3.8955	1.2153	2.2818	2.3683
Means	5.949^b	6.373^b	5.652^b	6.319^b	5.569^b	9.404^b	8.163^b	7.355^b	6.833^b

Note: Figures followed by the same letters are not statistically significant at 5% level according to the Least significant Difference (LSD) test.

Discussion

Temperature is an important factor as it greatly affects other properties of wastewater. Average temperature of wastewater under investigation was 25.553°C for all the stations and showed no significant difference from station to station at 5% significance level. The highest Air temperature was recorded in station E at 27.475°C, while the least was 25.690°C recorded at station B. No significant difference was observed for the water temperature at the stations. Difference was observed for the water temperature at the stations with the highest at E (26.370°C), and the lowest at station B, that is, 25.010°C. The highest mean temperature was observed in Sept. (for air) at 27.633°C, while for water same month was 26.967°C, temperature readings, generally were obtained in the mornings –between 0900hrs and 1000hrs. The values obtained were not higher than WHO standard of 40°C for discharge of wastewater in to streams.

The mean concentration of total dissolved solids (TDS) for the various stations shows that there is a significant difference (at 5% significant level). The highest mean concentration was obtained in station A, at 782.500ppm, while the lowest at 261.000ppm, was obtained at station C. There was also a significant difference in the mean concentration of the values from month to month. The values obtained for TDS for all the stations for the period of the research were not higher than WHO standard of 2000ppm for the discharge of wastewater into surface water.

Table 1 also displays the reading of the mean dissolved oxygen for the different stations while Table 8 displays the values obtained monthly from the different stations. The DO is a measure of the degree of pollution by organic matter, the destruction of organic substance as well as the self purification capacity of the water body. The DO can range in concentration from 0 to 14.6ppm. The amount of oxygen that can be dissolved in water is inversely related to temperature (Ramesh, 2004). The standard for sustaining aquatic life is stipulated at 5mg/l. the results obtained for all the stations at different period does not exceed the recommended value stated above, that is, 3.060ppm in June and 1.125ppm in July. This could be attributed to the effect of heavy rains as it comes along with debris from land making the soils rich in organic content, hence the monthly variation of the observed parameters.

The amount of chromium in the wastewater samples showed high values in station A, which is the raw untreated industrial waste from the chrome plating unit and goes to an all high value of 156.90ppm to as low as 0.009ppm at station F. The value of 25.206ppm recorded at station B comes from the treatment plant before going in to the settling tank. Station C recorded a value of 0.175ppm. This is the point of discharge in to the kakuri drain, hence the difference between the stations (from point of discharge) is not much and showed an average of 0.058ppm. This value is within the WHO set values for chromium in wastewater.

Lead showed very low values right from untreated wastewater at station A that recorded the highest value of 1.0236ppm, while the least value was recorded in station F, at 0.0280ppm.

Cadmium also showed low levels in all the stations except station A (2.8146ppm) and 0.06103ppm in the treated wastewater at station B, the rest stations had an average of 0.0392ppm.

The amount of copper from the electroplating unit of the DICON stood at 17.733ppm and this is due to its use in electroplating. The amount of copper found in the wastewater from the drain however shows very low values with the least value recorded at station F (0.8928ppm), while the average amount of copper in the drain from point of discharge of DICON effluents to where it empties in to river Kaduna shows a value of 1.08495ppm. This value is within the acceptable limits of copper in wastewater approved by WHO (0.05mg/L) for drinking water and 3.0ppm (mg/l) for industrial discharges.

The level of Zinc from stations C to F averaged a low figure of 0.452ppm which is within the safe limits as recommended by WHO of 5ppm.

The level of arsenic in the drain averaged 0.277ppm with the values of 0.031ppm at the point of discharge which was station C. The least value of 0.0098ppm was recorded at station E. The mean concentration of Phosphate and Sulphate (2.860ppm and 6.525ppm), as well as Nitrate-Nitrogen (2.030ppm) was found to vary from station to station. Positive correlation was noticed using the t-test. The mean values for Calcium in the samples were also significantly different from the other elements. The elements observed were found to be within the limit set by WHO and KEPA.

Conclusion

Heavy metals and Elements from the sampled wastewater analyzed, were found to be present in quantities within the recommended safe limits as set by the World Health Organisation (WHO). Except for Chromium at station C, no reading showed values above the recommended figures by the KEPA (1998). (Kaduna State Environmental Protection Authority), this was obviously due to the presence of the electroplating plant at a military factory. This was from samples collected at station C. Temperature is an important factor for the survival of all life forms. The temperature recorded in all the stations showed a relatively stable result not above critical temperature for wastewater as recommended by WHO.

Recommendation

The wastewater from the drain in the Makera industrial layout has not recorded values above the recommended values set by the World Health Organisation, WHO and KEPA. It is however good to note that it will not be safe to use such water for the irrigation of vegetable crops. This is due to bioaccumulation of heavy metals and other toxic substances in the crops which are invariably consumed by the community. It is therefore strongly recommended that the government takes measures in helping further reduce the level of such substances from industries prior to discharge.

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