DETERMINATION OF PHYSICOCHEMICAL PARAMETERS AND LEVELS OF SOME HEAVY METALS IN INDUSTRIAL WASTE WATER

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ABSTRACT : Physico-chemical parameters and levels of three heavy metals were determined in waste water samples collected from four selected chemical producing industries in Sango-Ota, Ogun-State, Nigeria using standard analytical procedure. Sampling was carried out between April and June, 2011. The results of the physico-chemical analysis were obtained in the following range; pH (5.48-10.35), temperature (31.0-33.50C), conductivity (43.8- 1927.45 µs/cm3), chloride (66.84- 5413.63mg/L), total hardness (148.55- 261.09 mg/L), sulphate (82.50-97.00 mg/l), TDS (21.249- 956.450 mg/L), alkalinity (412.56 -1233.41mg/L) ,TSS (68.963- 240.562 mg /L), BOD (460.07-1833.48 mg/ L), total nitrogen,(92.11- 252.18 mg/L), and sulphide(0.01-1.94). The concentration of some metals (mg/L) in the samples analysed were found to be in the following range; Cd (0.105- 0.427), Zn (0.228- 0.368), pb(0.351- 0.483), Na (29.46- 162.36), K (10.83-14.84) and Mg (0.985- 2.368). Some of the results were above the permissible limits set by Federal Environmental Protection Agency (FEPA) and World Health Organisation (WHO) most especially, effluent from ink/paint Industry. It can be concluded that all the effluents required further treatment before releasing them into water body or land in other to prevent pollution. Proper monitoring of industrial effluent by regulatory bodies and adequate measures should be put in place in other to curb indiscriminate release of industrial effluents to the environment.

Keywords: Waste-water, pollution, heavy metals, physiochemical analysis.

INTRODUCTION

Industrialization plays a vital role in growth and development of any country but, it has direct and indirect adverse effect on our environment. The continuous increase in industries has become sources of pollution. These industries include battery manufacturing, iron and steel, plastics, chemicals, fertilizer, textile, food and beverages, breweries, pharmaceuticals, soap, petroleum and petrochemical, automobile, tannery, paper mill and cosmetics, tobacco and paint industries [6]. The upsurge in urban population and the establishment of industries involved in the manufacture of various agrochemical,

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Industrial development include setting up of new industries and expansion of existing ones which resulted in the generation of toxic industrial effluents, that is often times discharged or released untreated to the environment leading to air, water, soil and soil solid waste pollution. It is alarming that most of the cities and industries in Nigeria are without wastewater treatment facilities. Groundwater is threatened with pollution from sources like; domestic wastes, industrial wastes, runoff from urban areas, suspended and dissolved soils, organics and pathogens. Wastewater treatment is not given the necessary priority it deserves and therefore, industrial waste and domestic sewage are discharged into receiving water bodies without treatment. The consequence of this is increased river pollution, loss of aquatic life and uptake of polluted water by plants and animals, which eventually gets into human body resulting in health related problems. In the third world, many surface waters are known locally to be very contaminated but these cases are rarely documented, due to lack of basic tools such as established monitoring network as well as logistical and analytical capacities [7]. The quality of drinking water in Nigerian cities has been deteriorated in the recent years mainly due to growth of population and improper disposal of waste water from industries [14]. Approximately 1.2 billion people in developing nations lack clean water because most household and industrial wastes are dumped into rivers and lakes without treatment contributing to many waterborne diseases in humans [5].

High levels of pollutants mainly organic matter in river water because an increase in biological oxygen demand, chemical oxygen demand, and total dissolved solids and total suspended solids. They make water unsuitable for drinking, irrigation [11] or any other use.

Mismanagement of these wastes which are dumped in soils and unsanitary landfills are subjected to weathering and leaching processes by rain and other atmospheric influences resulting in the release of hazardous substances such as cyanides, minerals, heavy metals and organic acids which get to underground water systems and inland water bodies untreated. Their effects render underground and surface waters unsafe for human, recreational and agricultural use. Biotic life is destroyed and natural ecosystems are poisoned. Human life is threatened and the principle of sustainable development is compromised [12] . Some of the heavy metals commonly found in industrial waste water include: lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg) etc. The pH of the wastewater may affect the quality of the water by increasing the toxicity of the metal as the pH decreases.

Industrial effluents not only contain toxic materials but also have other nutrients that enhance the growth of crop plants. Therefore it is essential that the implications of the use of industrial effluents in the crop field and their effect on soil characteristics should be assessed before they are recommended for use in irrigation.

The aim of this study was to determine some physiochemical parameters and the concentrations of some heavy metals in effluent discharges from four industries which are; a plastic industry (A),two chemical manufacturing industries (B and C) and an ink/paint industry(D). The two chemical industries produce both industrial and laboratory chemicals ranging from coatings, soap chemicals etc., the ink/paint industry produces different types of ink and paint for commercial use and the plastics industry which produces a brand of popular storage tanks also produces rubber that is used for human hair. These levels were compared with the maximum permissible levels stipulated by FEPA [9] and WHO [15].

MATERIALS AND METHODS

SAMPLE COLLECTION

Samples were collected from four different industries in duplicate. Sampling was carried out using well cleaned amber bottles (2L) that are air tight from the effluent reservoir tank of each company. Sampling bottles were pre-cleaned by soaking them in detergent for 24hours, followed by rinsing with tap water and then rinsed with 5% nitric acid and lastly with distilled water [1] the water samples were preserved with 1ml conc. HNO_3 and stored at 4^oC until use. Samples were kept in a portable cooler containing ice, to maintain an inert temperature condition for the effluent and were transported to the laboratory for analysis.

The physico-chemical analysis done includes: i.e. The pH, conductivity, alkalinity and total solids. All field meters and equipment were checked and calibrated according to the manufacturer's specifications. The pH meter was calibrated using [10] buffers of pH 4.0, 7.0 and 10.0. The pH was measured using an Orion pH meter, A conductivity meter measured the conductivity and the alkalinity was determined by titration method while the total dissolved solids were determined using gravimetric analysis.

Physical and Nutrient load analysis

The following physical parameters were assessed using standard methods for examination of

water and wastewater [2] ; pH, total solids (TS), total hardness, total organic carbon (TOC), dissolved oxygen (DO), chemical oxygen demand (COD) and bicarbonates. Nutrient Load was assessed using the following parameters: phosphates, sulphates, nitrite, nitrate and total nitrogen. Water samples were filtered using whatman filter paper No 4 before analysis in order to remove suspended particles. All chemicals used were of analaR grade. Each sample was digested using a mixture of 10ml each of 40% HF and 70% $HClO_4$ in a fume chamber. The resulting clear colourless solution was allowed to cool down, filtered and made to 100 ml with deionised water and finally stored in a polythene container in readiness for instrumental analysis. The heavy metal analysis was also done using the Atomic Absorption Spectrophotometer Unicam 969 model.

Table 1: Physical parameters of each company

S/N	Parameters	FEPA Limit	A	B	C	D
1	pH	6-9	7.18 ±0.12	10.35 ±0.09	5.69± 0.11	5.48± 0.07
2	Colour		Dull-whitish	Whitish-cream	Bluish-black	greenish
3	Temperature ^0C	40 ^0C	33.4± 0.2	33.5± 0.1	31.5± 0.4	31.0± 0.3
4	Turbidity(NTU)		200± 015	5800± 1200	5200± 1150	5500± 1000
5	Conductivity µs/cm^3	1000	43.86 ±1.20	1927.45±2.20	240.20±2.00	461.00±1.80
6	TSS mg/l	30	5.883 ±0.09	240.562±0.	68.963±1.8	126.920±1.

			0	120	00	400
7	TDS mg/l	2000	21.249±0.080	956.450±1.850	112.520±1.250	219.540±1.860

Table 2: Biological and Chemical parameters for the four company

S/N	Parameter (mg/l)	FEPA Limit	A	B	C	D
1	Chloride	600	66.84±1.10	5413.63±0.70	616.43±1.98	1321.40±2.10
2	Total nitrogen		92.11±1.00	106.53±1.35	252.18±1.77	246.99±2.11
3	Total alkalinity	250(WHO)	412.56±0.09	629.41±1.09	1126.72±1.67	1233.41±2.10
4	Total hardness		148.55±1.37	182.46±1.49	240.47±1.48	261.09±1.67
5	Sulphides S^{2-}	0.2	0.01±0.03	0.02±0.01	1.25±0.45	1.94±0.06
6	Na		32.62±1.00	29.46±0.90	162.36±0.49	156.31±0.08
7	K		14.84±0.23	13.75±0.08	12.57±0.09	10.83±0.03
8	Mg		0.985±0.001	2.368±0.002	1.282±0.005	1.736±0.011
9	BOD	50	460.07±1.12	790.11±2.01	1732.17±1.99	1833.48±2.09
10	COD	80	952.46±2.29	1392.75±3.12	2584.50±2.55	2713.43±2.78

Table 8: Heavy metals

S/N	Heavy metal (mg/l)	FEPA Limit	A	B	C	D
1	Cd	0.1	0.105±0.004	0.214±0.011	0.296±0.005	0.427±0.010
2	Zn	0.1	0.246±0.001	0.228±0.012	0.342±0.003	0.368±0.002
3	Pb	0.1	0.351±0.003	0.402±0.001	0.414±0.000	0.483±0.005

RESULTS AND DISCUSSION

Industrial effluents are the main source of surface and ground water pollution. To evaluate the pollution content of industrial effluent, four samples in duplicate the four industries were analyzed for various physical and chemical parameters such as temperature, pH, electrical conductivity (EC), total suspended solids (TSS), total dissolved solids (TDS), biological oxygen demand (BOD) and heavy metals. The results were compared with the standard values of Federal Environmental Protection Agency (FEPA) for industrial effluents, United States- Environmental Pollution Agency (US-EPA) and World Health Organization (WHO) for drinking water given in.

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Temperature:

Temperature is basically important for its effect on other properties of wastewater. Temperature values for various samples are presented in Table-1, ranging from 31.0-33.5^{0}C. The highest value was found in the sample B followed by, A and C, while sample D has the lowest temperature. The temperature values of all the samples analysed were within the permissible limits of FEPA and WHO. Release of high temperature waste water into water bodies may speed up some reactions in the water body. It will also reduce solubility of oxygen and amplified odour due to anaerobic reaction (less oxygen).

Turbidity

The values obtained for turbidity values for the four samples were higher than WHO standard of 5 NTU for discharged of wastewater into stream. High turbid waters are often associated with the possibility of microbiological contamination, as high turbidity makes it difficult to disinfect water properly [8].

pH:

The pH of the samples ranged from 5.48-10.35 so presented in Table-1. Sample D has the lowest (5.48), while sample B has the highest pH value of 10.35. All the pH values were within the permissible limits for industrial effluents set by FEPA except sample B. The pH of samples C and D are below the permissible standard for drinking water set by USEPA and W.H.O while the pH of sample B was found to be above the standard.

Electrical conductivity EC:

Conductivity of water which is a useful indicator of its salinity or total salt electrical conductivity is a useful indicator of mineralization and salinity or total salt in a water sample. EC of the samples shown in Table-1, ranged from 43.86±1.20 to 1927.45±2.20 µs/cm^3. Sample B has the highest EC of 1927.45±2.20 µs/cm^3, while sample A has the lowest EC. The mean conductivity values for all the samples were below the WHO guideline values of 1000µScm^{-3} for the discharge of wastewater through channel into stream except that of sample B.

Total suspended solids TSS:

The TSS values (Table-1) of the samples ranged from 68.963±1.800 to 240.562±0.120 mg L^{-1}. FEPA standard for TSS is 30 mg L^{-1}. So it is clear that all the samples have very high TSS values which may be due to the fact that the waste contains many suspended particle. The maximum value of TSS (240.562±0.120 mg L^{-1}) was recorded in the effluent of sample B. Effluents of such high TSS may cause handling problem, if directly applied to agricultural field, or if this effluent is discharged to river or stream, it will make it unsuitable for aquatic life. Literature classified wastewater TSS as follows: TSS < 100 mg/l as weak, TSS > 100 mg/l as but < 220 mg/l as medium and TSS > 220 mg/l as strong wastewater. Therefore, waste water from B is strong and cannot be discharged into stream.

Total dissolved solids TDS:

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The TDS values of the samples ranged from 21.249±0.080- 956.450±1.850 mg L^{-1} (Table-1). The lowest value was found in sample A while the highest value was found in sample B. The FEPA standard for TDS is 2000 mg L^{-1}. All the samples have values within the permissible limit. High TDS is caused by high solids loading.

Biological and Chemical oxygen demand BOD & COD:

An indication of organic oxygen demand content of wastewater can be obtained by measuring the amount of oxygen required for its stabilization either as BOD and COD. Biological Oxygen demand (BOD) is the measure of the oxygen required by microorganisms whilst breaking down organic matter. While Chemical Oxygen Demand (COD) is the measure of amount of oxygen required by both potassium dichromate and concentrated sulphuric acid to breakdown both organic and inorganic matters The BOD values ranged from 460.07±1.12 to1833.48±2.09 mg L^{-1} as presented in Table-1.The COD values ranged from 952.46±2.29- 2713.43±2.78 mg/L. Sample A has the lowest BOD and COD while sample D has the highest BOD and COD. These effluents on entering fresh water (rivers, stream etc) make the O_2 depleted, causing suffocation of fish and other aquatic fauna and flora resulting in the death of aquatic life. The concentrations of BOD and COD in all the samples were higher than the WHO and FEPA values of 50 mg/l and 1000mg/l for the discharged of wastewater into stream. High COD and BOD concentration observed in the wastewater might be due to the use of chemicals, which are organic or inorganic that are oxygen demand in nature.

Anionic Analysis

The chloride level of the samples measured fall within this range 66.84±1.10- 5413.63±0.70mg/L. Chloride levels in sample B, C and D were found to be above the permissible level (600mg/L). The concentrations of total nitrogen, total alkalinity, total hardness and sulphide in all the samples analysed varied between 92.11±1.00- 252.18±1.77 mg/l for total nitrogen; 412.56±0.09 to1233.41±2.10 mg/l for total alkalinity; 148.55±1.37to 261.09±1.67 mg/l for total hardness and 0.01±0.03 to1.94±0.06 for sulphide respectively (Table 1). Sulphide levels in samples C and D were found to be above FEPA permissible level. Hydrogen sulphide is formed under conditions of deficient oxygen in the presence of organic materials and sulphate [15]. This could be a possible reason for the high sulphide measured in the effluents analyzed. The levels of nitrate exceeded the WHO limits of 45mg/l for nitrate in wastewater, The levels of nitrogen may give rise to methaemoglobinemia, also the levels of nitrogen reported in this study in addition to phosphate levels can cause eutrophication and may pose a problem for other uses.

Heavy metals:

Investigated metals in the industrial effluents of various industries are presented in Table-2. The composition of metals in the wastewater samples

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ranged from 0.105±0.004 to 0.427±0.010 mg/l for Cd; 0.228±0.012 to 0.368±0.002 mg/l Zn; 0.351±0.003 to 0.483±0.005 mg/l Pb; 29.46±0.90 to 162.36±0.49 mg/l Na; 10.83±0.03 to 14.84±0.23 mg/l K and 0.985±0.001 to 2.368±0.002 mg/l Mg. The concentrations of metals in the samples analysed are in the following order Na>K>Mg>Pb>Cd>Zn. While Na, K and Mg can improve crop yield, only trace amount of Zn is required but, Pb and Cd are toxic. Highest amount of all the heavy metals analysed were found in sample D while, the lowest amount of Cd and Pb were found in sample A. The concentration of heavy metals (Pb, Cd and Zn) in all the samples analysed were far above the maximum permissible level recommended by FEPA and WHO.

Conclusion

Based on the result of this analysis the order of the level of contaminants in the samples analysed collected from the four chemical producing industries may be assumed to follow this sequence, D>B≈C>A. The concentration of contaminants in all the effluents studied were mostly above the set limits by the Federal Environmental Protection Agency (FEPA) in Nigeria and some world bodies like the World Health Organization. Though, the effluents were found to be rich in plant nutrients required for plant growth but due to the presence of high levels of toxic heavy metals, these waste water may not be good for irrigation in other to avoid accumulation of these metals in soils, and if the effluent are released into the environment without proper treatment, it may affect underground water and aquatic life if released into water bodies without proper treatment.

Recommendation

Government should assist in the review of old regulations, and introduce new standard for effluent discharge. Regular monitoring by regulatory bodies should be encouraged in other to instil total compliance. Awareness should be created among the industrialists, workers and the inhabitants on friendly environmental activities. The national Environmental Quality Standards (NEQS) regarding wastewater should be strictly enforced on these industries to install wastewater treatment plants.

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