CHARACTERISTICS OF A PHARMACEUTICAL EFFLUENT AND ITS PHYSICO-CHEMICAL VARIABLES IN MINNA, NIGER STATE. NIGERIA

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ABSTRACT

There is persistent deterioration in environmental water quality and a loss of biodiversity habitats in the surrounding community due to the Industrial effluents, wastes and emissions containing toxic and hazardous substances most of which can be detrimental to human health and Biodiversity.The physico-chemical and heavy metals evaluation of effluent from a pharmaceutical industry Located in Minna Niger State were determined to find out the impact on the environment. The physico-chemical parameters assessed includes pH, Total Dissolve Solids (TDS), Electrical Conductivity Using (Hanna microprocessor pH/EC/TDS meter), Dissolve Oxygen(DO) using Dissolve Oxygen Analyser, model JPB-607, Air temperature, Total hardness(TH), Total Alkalinity(TA), Biological Oxygen Demand(BOD), Chemical Oxygen Demand(COD), Nitrate, Phosphate, carbon (IV) oxide, chloride Using Titration Method and water temperature Using a Mercury in glass Thermometer. Heavy metals Studied include: copper, Iron, Lead and Manganese. Physico-chemical Parameters were determined using standard methods, while heavy metal levels were determined using Atomic Absorption Spectroscopy (AAS) (Spectra AA Varian 400 plus). All data were analyzed using two-way ANOVA. The results indicates that pH Ranged (3.09-3.57) was acidic among the Stations, Total Alkalinity (38.29-124.57mg/l), Total Hardness (70.14-481.14mg/l), Biological Oxygen Demand (2.9-411.00mg/l), Chemical Oxygen Demand (8.21-22.15mg/l), Phosphate (2.8-9.19mg/l). All the results were above the acceptable standard set by World Health Organisation (WHO,2011),While, Nitrate (5.23-29.75mg/l) and Chloride (28.22-107.69mg/l) fell below the acceptable limit set by Nigerian Industrial Standard (N.I.S,2015) and (WHO,2011).Also, the concentration of heavy metals obtain from sediment sample are Lead (0.14-0.86mg/l), Iron (139-214mg/l), copper (0.53-1.28mg/l) and Manganese(0.21-6.07mg/l) and in wastewater are Lead (0.14-0.86mg/l), Iron (0.51-3.53mg/l), copper (0.25-1.38mg/l) and Manganese (0.29-1.90mg/l) respectively, the level of heavy metals analysed are all above the WHO permissible limit, except copper in both cases which was below the standard. This study reveals the need for enforcing adequate effluent treatment methods before their discharge to surface water and sediment to reduce their potential environmental hazards on the community and damage to the entire ecosystem.

Key Words: Characteristics, Pharmaceutical, Effluents, Physico-Chemical Variables

Introduction

Pharmaceutical effluents are wastes generated by pharmaceutical industries during the process of drugs manufacturing. Their risk to human health cannot be overemphasized. In Nigeria, the increase in demand for pharmaceuticals has resulted in a consequent increase in pharmaceutical manufacturing companies in the country and hence increased pharmaceutical waste which most times contain heavy metals. These effluents are discharged into the environment and when improperly disposed, they affect both human health and the environment (Osaigbovo and Orhue, 2006). The uncontrolled use of pharmaceutical products now constitutes a new challenge. Most pharmaceutical effluents are known to contain concentrations of organic compounds including heavy metals and other toxic compounds (Anetor *et al.*, 2000). Due to mutagenic and carcinogenic properties of heavy metals, much attention has been paid to them since they have direct exposures to humans and aquatic organisms (Momodu and Anyakora, 2010). These metals tend to bio-accumulate and are stored faster than excreted (Lenntech, 2006). Recently, the increased demand of the pharmaceuticals has generated a large number of its manufacturing units all over the globe and hence, the increased in pharmaceutical wastewater (Robert, 1991). Total solids including heavy metals are potential ingredients having toxic characteristics to affect the soil, surface and ground water (Ramoda and Singh, 2013), which have adverse effects on the human health and living biota (Oktem *et al.*, 2007).

This study was aim at determining the presence of four (4) heavy metals, namely Lead, Iron, Copper and Manganese in the effluents of pharmaceutical company in Minna, Niger State, Nigeria. The results obtained may form the basis for intervention by encouraging the pharmaceutical company to effectively treat their effluent before discharge into the environment or percolate into underground Wells which is their main source of drinking water.

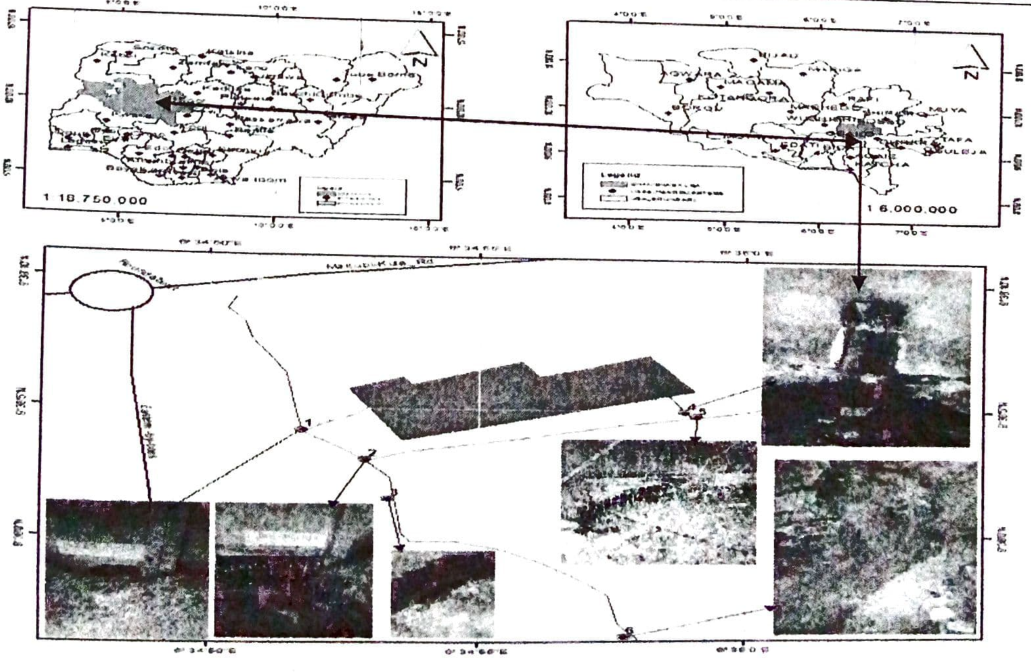
MATERIALS AND METHODS

Description of Study Area

The pharmaceutical company is located in industrial layout Minna, Niger state and is geographically located between longitude Latitude 9° 38'6.22 N, Longitude 6° 34'50.77 E at an altitude of about 299m above sea level. Its covers an estimated land area of 74,244sq.km. the climate in Minna is characterised by two distinct seasons i.e. the wet season between April to November with a mean annual rainfall of 1334mm and the highest mean monthly rainfall is august and September with about 300mm. the dry season is between November to march with February and march been the hottest month. The mean annual temperature and relative humidity of the area is 30.2°C and 61% respectively. The study area was selected due to the presence of pollutants such as industrial discharge (sewage) into the environment.

Location (G.P.S.) of Discharge point of the Pharmaceutical Industry, Minna, Niger state.

Station No.	Description	G.P.S. location
Station 1	Rain drain	Latitude 9° 38'6.22N, Longitude 6° 34'50.77 E
Station 2	Rain drain	Latitude 9° 38'2.84 N, Longitude 6° 34'52.13 E
Station 3	Meeting point of S1 & S2	Latitude 9° 38'4.90N, Longitude 6° 34'58.85 E
Station 4	Discharge point	Latitude 9° 34'4.73N, Longitude 6° 34'59.08 E
Station 5	Discharge point	Latitude 9° 38'1.71N, Longitude 6° 34'52.86 E
Station 6	Along the end point	Latitude 9° 37'56.47N, Longitude 6° 34'58.10 E



Map of the study Area showing Location of Sampling points.
Source: Remote sensing Laboratory, Geography Department, Federal University of Technology, Minna.

Samples collection

Wastewater and Sediments Samples were collected from the surroundings of Pharmaceutical industrial in Minna. The samples were collected in clean, dry polyethylene bags/bottles and collected from six points designated as S1 to S6, point S1 was at the point of discharge of waste water into the drain, S2 was 50 meters from point S1, S3 was 100 meters from point S1, and S4 was also a point of discharge of waste water into the drain, S5 was 100 meters up the river away from the point of discharge in to the river to serve as control. Point S6 was 100 meters from point S5. Water and sediment samples were collected monthly for six months in the dry and rainy seasons. The physical and chemical parameters for the effluents were determined using standard methods. The samples were stored in a cool place prior to digestion for heavy metals analysis.

Water and sediment samples Digestion for Heavy Metals Analysis

Sediment was weigh, transferred into a conical flask, 10ml of concentrated trioxonitrate (IV) acid, (HNO_3) and 10ml of HCL was added and the resulted mixture was place in hot water bath to boil for 45minutes. It was further boil to release white fumes. After cooling, 20ml of distilled water was added and further heated until a clear solution was obtained, the mixture was filtered into a volumetric flask using Whitman filter paper(size 110mm); distilled water was added to reach the $50cm^3$ mark. Labelled and ready for heavy metals analysis using AAS. (Spectra AA Varian 400 plus) consisting of a hollow cathode lamp, slit width of 0.7 nm and an air acetylene flame was used for analysis.

Chemicals and reagents

All chemicals and reagents were of analytical grade and were obtain from BDH Chemicals Ltd, UK. Conc. HNO_3 was used for the digestion of the samples while corresponding metal salts [namely: $CdCl_{12}.H_20$, $Cu(SO_2)_2$, $Zn(SO_2)_2$, $Pb(NO_2)_2$, $NiC_{12}.6H_2O$ and $Cr(NO_3)_3$,] were used as standards.

Data Analysis

Two-way ANOVA was use to determine the mean and Standard deviation, minimum and maximum of physico-chemical parameters and the heavy metal concentration in the wastewater and sediments readings.

Results and Discussion

A calibration curve was obtain using a series of varying concentrations of the standards for all four metals. Calibration curve for all the metals were linear with a correlation coefficient of approximately one. The effluents analyzed contain some heavy metals in varying concentrations. Tables 1 is a summary of the Physicochemical parameters of the study, While Tables 2 and 3 give the summary of the results obtained in Water and Sediments in this study, while, Table 4 summarizes guidelines set by different international and National Industrial Standard agencies.

Table 1. Summary of the Physicochemical parameters of Effluent from pharmaceutical industry in Minna

Parameters	1	2	3	4	5	6	F-Value		P-Value	
							Months	Stations	Months	Stations
Conductivity	26.71±14.33 (0-92)	61.57±15 (2-13)	68.14±12.64 (3-94)	13.14±49.82 (4-32)	53.43±15.76 (5-13)	33.57±68.17 (6-50)	3.91	3.67	0.01	0.01
pH	3.09±1.39 (0-8.16)	6.28±1.29 (2-11.88)	7.9±0.00 (3-11.97)	6.83±1.51 (4-12.45)	6.43±0.48 (4.93-8.04)	3.57±6.17 (6-50)	4.19	3.49	0.003	0.013
TA(mg/l)	38.29±24.39 (0-175)	124.57±35.48 (2-280)	87.71±35.60 (3-266)	79±13.35 (4-115)	84.86±18.63 (5-138)	91.71±19.87 (6-144)	2.74	1.47	0.03	0.23
TH(mg/l)	70.14±41.13 (0-286)	230±100.13 (2-784)	413.29±118.56 (3-850)	481.14±112.64 (4-790)	219.29±41.61 (5-320)	141.43±35.77 (6-320)	6.03	6.94	0	0
BOD(mg/l)	4.3±2.66 (0-16.3)	4.11±2.32 (0.15-14)	2.91±1.46 (0.15-8.7)	3.63±2.03 (0.2-14.6)	3.69±1.76 (0.2-10)	3.97±1.88 (0.15-11.4)	52.48	0.55	1.42E-14	0.74
COD(mg/l)	8.21±3.82 (0-22.5)	20.21±3.54 (2-28)	17.58±3.07 (3-25.8)	22.15±3.47 (4-33.6)	19.31±3.17 (5-32.4)	16.6±2.54 (6-27.0)	5.82	3.95	0	0.01
NO_3(mg/l)	5.23±3.56 (0-26)	18.37±5.19 (2-31.2)	29.75±9.46 (3-55)	26.36±5.49 (4-42)	27.68±9.60 (5-75.5)	18.85±4.31 (4.53-33)	19.27	4.33	9.06E-06	0
PO_4(mg/l)	2.8±2.31 (0-16.6)	9.17±2.92 (0.48-19.5)	14.47±6.51 (6.95-50)	13.55±5.87 (0.63-46.5)	7.82±2.24 (0.77-18.3)	9.19±2.30 (0.52-14.6)	6.37	2	0	0.11
CO_2(mg/l)	6.21±2.84 (0-15.89)	11.67±2.15 (2-21.34)	16.77±2.93 (3-29.51)	13..1±1.96 (4.21.26)	10.79±1.32 (5-15.75)	13.59±1.41 (6-17.65)	6.96	5.11	0	0
Cl_2(mg/l)	28.22±14.24 (0-84.54)	66.78±13.97 (2-126.5)	67.78±12.24 (3-94.6)	107.69±30.39 (4-230.95)	61.97±13.22 (5-120.26)	54.67±14.83 (6-130.5)	10.87	5.61	2.02E-06	0
Water temp	13.29±6.15 (0-31.9)	27.54±4.26 (2-32.5)	26.84±3.99 (3-32.5)	27.1±3.86 (4-32.5)	27.34±3.73 (5-31.8)	28.1±3.71 (6-32.9)	13.28	5.31	2.70E-07	0
TDS(mg/l)	1.16±0.53 (0-3.38)	7.56±1.21 (2-10.2)	8.07±1.28 (3-12.65)	9.58±1.16 (4-12.43)	5.36±0.17 (4.7-6.04)	5.08±0.95 (1-8.2)	2.49	11.67	0.04	2.55E-06
DO(mg/l)	0.97±0.37 (0-2.1)	2.13±0.12 (1.8-2.7)	2.31±0.15 (1.9-3)	2.59±0.29 (1.7-4)	2.43±0.46 (1.6-5)	2.97±0.52 (2.1-6)	4.06	5.73	0	0

Mean and Standard Deviation, Minimum and Maximum Range of Physicochemical Parameters of Effluent of pharmaceutical industry in Minna.

Table 2. Heavy metals concentrations of Effluent from pharmaceutical industry in Minna

	STATIONS						2-Way ANOVA			
							F-Values			P-Values
	1	2	3	4	5	6	Months	Stations	Months	Stations
Pb+	0.14±0.14	0.29±0.29	0.44±0.29	0.58±0.57	0.72±0.71	0.86±0.86	20.93	0.99	1.72E-09	0.43
	(0-1)	(0-2)	(0-2)	(0-4)	0-5	(0-6)				
Fe+	0.56±0.19	0.51±0.25	3.44±1.14	3.53±1.38	1.49±0.61	2.14±0.75	0.72	2.42	0.64	0.06
	(0-1.01)	(0.2-2)	(0.4-10)	(0.1-10)	(0.3-5)	(0.4-6)				
Cu+	0.25±0.33	0.35±0.27	0.56±0.41	0.80±0.54	0.79±0.70	1.38±0.79	19.71	2.44	3.48E-09	0.06
	(0-1)	(0.01-2)	(0.02-3)	(0.03-4)	(0.04-5)	(0.05-6)				
Mn+	0.29±0.14	1.90±1.37	1.12±0.43	0.76±0.54	0.86±0.69	1.28±0.80	3.03	0.67	0.02	0.65
	(0-1)	(0.09-10)	(0.04-3)	(0.02-4)	(0.05-5)	(0.04-6)				

Mean and Standard Deviation of Concentration of heavy metals in wastewater samples

Table 3: Heavy metals concentrations of Effluent sediments from pharmaceutical industry in Minna

	STATIONS							2-Way ANOVA		
								F-Values	**P-Values**	
	1	**2**	**3**	**4**	**5**	**6**	**Months**	**Stations**	**Months**	**Stations**
Pb+	0.14±0.14	0.29±0.28	0.45±0.43	0.57±0.57	0.75±0.71	0.86±0.86	20.93	1.04	1.73E-09	0.41
	(0-1)	(0-2)	(0-3)	(0-3)	(0-5)	(0-6)				
Fe+	156±51.00	139±33.78	165±57.19	207±61.88	214±62.15	195.28±55.68	131.78	7.04	3.53E-20	0
	(1-312)	(2-231)	3-331)	(4-380)	(5-380)	(6-361)				
Cu+	0.53±0.17	0.84±0.24	0.73±0.38	0.85±0.53	1.19±0.66	1.28±0.79	14.43	1	1.13E-07	0.43
	(0.05-1)	(0.12-2)	(0.15-3)	(0.1-4)	(0.08-5)	(0.14-6)				
Mn+	5.36±1.63	4.25±0.93	6.07±1.89	1.72±0.4	0.21±0.49	5.10±1.44	7.56	4.11	5.34E-05	0.005
	1-10.2)	(2-7.2)	(1.15-11.8)	(0.89-4)	(1.02-5)	(1.11-8.9)				

Mean and Standard Deviation of Concentration of heavy metals in Sediment samples.

Table 4. Standard for Heavy Metals in mg/L

Heavy metals Mg/L	NIS,2015(mg/l)	USEPA,1999(Mg/l)	WHO, (2008 and 2011)
Lead (Pb^{2+})	0.01	0.003	0.01mg/L
Iron (Fe^{+})	0.3	0.3	0.1 mg/L
Copper (Cu^{+})	1	0.009	2 mg/L
Manganese (Mn^{+})	0.2	0.05	0.05 mg/L

DISCUSSION

The physic-Chemical parameters of the wastewater samples collected were high in Electrical conductivity throughout the stations indicating the content had high metals to conduct electric current with the pH showing high acidity in station 1 and 6, while slight changes occurs in stations 2,3,4 and 5which indicate fluctuation in the concentration. This may be due to the nature of the discharge from this station. The pH of effluent from stations 1 and 6 was acidic (3.09±1.39 and 3.57±6.17) respectively. The acidic nature of these stations is capable of stemming the pH of the receiving water bodies thereby destabilizing fundamental properties such as alkalinity, metal solubility and hardness (Olaitan *et al.,* 2014). The temperature was generally high, which also affect the conductivity; dissolve oxygen and total dissolve oxygen. The monthly fluctuation of the parameters could be due to rainfall that reduce temperature and dilute the wastewater concentration along the stream flow (Sagar *et al.,* 2012). Total alkalinity was generally high with the highest value in station 2(124.57±35.48). Although, no acceptable standard is set by standard organizations, the nature of the effluent and the effect of pH may influence the total alkalinity (Wang *et al.,* 2002). The concentration of the nitrates, phosphates and chlorine in the six (6) stations were above the World Health Organization (WHO, 2011) and United States Environmental Protection Agency (USEPA 1999) Standards, even though some effluent has the lowest value for these nutrients. This may be due to the raw materials used in drug production in this industry, which have high concentration of nitrate, phosphorus, and chlorine (Olaitan *et al.,* 2014). The BOD value were generally low, The low DO values from all the stations compared with WHO (2011) standards indicates that these industry produced many organic substances with high oxygen-demanding wastes (Emongor *et al.,* 2005). High level of alkalinity could be as a result of low DO. High phosphorus salt found in the pharmaceutical effluent could be attributed to detergents used for washing in the factory and this could serve as a source of hardness of the effluents (Onianwa *et al.,* 1999). The TDS and Chlorine values for all the station where below maximum permissible limit set by Federal Environmental Protection Agency (FEPA, 1991). The mean values of the physico-chemical parameters of the pharmaceutical industry effluents and sediments at their point of discharge were higher than the discharge specifications set by the regulatory bodies, since these values were out of range required by standards, it is therefore suggested that these wastewaters was not treated before discharge.

Table 2 and 3 shows the concentration of heavy metals in the effluents and sediment analysed. Lead concentration was above the maximum acceptable limit of (0.015mg/l) set by WHO (2011) as indicate on table 4 below. Lead poisoning could cause abdominal pain, loss of appetite, insomnia and constipation. Severe kidney and brain damage has been reported on long-term exposure (Momodu and Anyakora, 2010). This heavy metals discharge may end up in drinking water and food chain. Manganese values recorded were above the maximum acceptable limit set in both the wastewater and sediment In all the samples (NIS, 2015; WHO, 2011). This could cause neurological disorder in human when it bio-accumulate and bio-magnify in the aquatic ecosystem, it could also affect biota (Vineeta *et al.*, 2017). Copper was also below the maximum acceptable limit (WHO, 2011; FEPA, 2014), both wastewater and the sediment except in station 6 (1.38±0.79) in the effluent and station 5 and 6 (sediment) which have mean values above the standard set (USEPA, 1999). Although, this is a trace metals that is essential to humans, it is potentially toxic at high concentration because they act on the cell membrane or interfere with cytoplasm to cause gastrointestinal disorder (Amuda *et al.*, 2007). There is relatively high concentration of Iron in both samples (wastewater and sediment). All the concentration were above the maximum acceptable limit set (USEPA, 1999; WHO, 2011; NIS, 2015). Sediment has extremely high concentration of this metal, which could lead to an uptake by plants and biological species within the ecosystem. In all points, the concentration of the different metals in the effluents fluctuate significantly given credence to the fact that the metals are due to the manufacture of a particular product or drug.

Conclusion

Toxic substances need to be discharge properly. The human health of the community need to be address, the aquatic resources within the community streams are essentials visa vie the humans that consume the Biotic and abiotic resources alone the food chain, some of the heavy metals percolate into the water table and reach the wells dug by the inhabitants of the community in search for drinking water. The publication of this research will draw the attention of Government on the need for the industry to clean up the drains and wetlands that are affected by these effluents. Dug wells drinking water sources should be control within the affected community.

Recommendations

Traditional wastewater treatment methods, such as activated sludge, are not sufficient for the complete removal of active pharmaceutical ingredients and other wastewater constituents from these waters. Pharmaceutical effluents especially near pharmaceutical industrial zones directly or indirectly affect environment and health. Pharmaceutical waste is a form of medical waste that includes unused medications, and occasionally frills such as used test strips, and other supplies. Pharmaceuticals are synthetic chemicals belonging to a wide group of different chemical families and may react different in the environment. Pharmaceuticals are special kinds of chemicals. They are manufactured to be biologically active in living organisms, to be persistent to biodegradation and to have long half-lives. This makes them more risky in nature. Release is ongoing always and everywhere, diffuse and impossible to control. They cannot be ignored. There is a need of regular monitoring of concentration of pharmaceutical compounds and enforcement of effluent treatment to reduce such environmental and health hazards, this should be enforce by the State government environmental protection agency in collaboration with the Federal Environmental agency(FEPA).

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