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ORIGINAL ARTICLE

Pharmaceutical Industrial Effluent: Heavy Metal Contamination of Surface water in Minna, Niger State, Nigeria

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ABSTRACT
Pharmaceutical effluent and surface water from River Gorax Maitumbi industrial layout Minna, Niger State, Nigeria were Sampled at eight different points designated as S_1 to S_8. Elemental analysis was conducted over a period of 3 months, using Perkin-Elmer Analyst 300 Atomic Absorption Spectroscopy (AAS). The result shows that of the level of the elements was found to vary between the sample points. For instance S1 (the first sampling point in the drain) had the highest value of Fe (9.2 mg/l) whereas S8 (the last sampling point in the river) has the least value of (1.08mg/l). Zinc was observed to have the lowest value of (0.05mg/l) in the control whereas the highest value comes from S1 (2.25 mg/l), Copper was observed to have the lowest value of (0.02 mg/l) in the control and S8 whereas the highest value was observed at S1 (0.15 mg/l), Cobalt was not detected at points S1 to S7 (second to the last sampling point in the river) whereas S8 has (0.08 mg/l), Manganese was observed to have the lowest value of (0.44 mg/l) in the control whereas the highest value of (1.20 mg/l) was observed in the control, Cadmium was only detected at points S1 to S2 (the second sampling point in the drain) with the values (0.01 and 0.06 mg/l), Nickel was observed to have the lowest value of (0.06 mg/l) in the control whereas the highest value was observed in the samples from (S1) (0.22 mg/l) and Lead was not detected in the samples from (S5) to (S8) in the river whereas the highest value was observed at S1 (0.09 mg/l) and the least of (0.01 mg/l) were observed at S3(the third sampling point in the drain), S4(the meeting point of the effluent with river), and S7. The concentration of these parameters contained indicated that the River is fairly polluted. This study reveals the need for enforcing adequate effluent treatment methods before their discharge to surface water to reduce their potential environmental hazards.
Key words*: Pollution, environment, AAS, Maitumbi, Road, plastic container*

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INTRODUCTION

Pharmaceutical effluents are waste generated by pharmaceutical industry during the process of drugs manufacturing. Pharmaceutical and personal care products industries suffer from inadequate effluent treatment due to the presence of recalcitrant substances. Some of the most representative pharmaceutical and personal care products found in receiving waters include antibiotics, lipid regulators, antiinflammatories, antiepileptics, tranquilizers, and cosmetic ingredients containing oil and grease [1]. Heavy metals are chemical elements with a specific gravity that is at least 5 times the specific gravity of water. The specific gravity of water is 1 at 4°C (39°F). Simply stated, specific gravity is a measure of density of a given amount of a solid substance when it is compared to an equal amount of water [2]. Heavy metals are dangerous because they tend to bioaccumulate and can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater. Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs [3]. Heavy metals are not biodegradable and tend to accumulate in living organisms, causing various diseases and disorders [4, 5]. In small quantities, certain heavy metals are nutritionally essential for a healthy life. Some of these are referred to as the trace elements (e.g., iron, copper, manganese, and zinc). These elements, or some form of them, are commonly found naturally in foodstuffs, in fruits and vegetables, and in commercially available multivitamin products [6]. Allergies are not uncommon and repeated long-term contact with some metals or their compounds may even cause cancer [6]. Most of the metals are known to be toxic and half of these, including cadmium, chromium, copper, lead, mercury, nickel, selenium, silver and zinc, are released into the environment in quantities that pose a risk to human health [7]. Metals can often be precipitated out by changing the pH or by treatment with other chemicals. Many, however, are resistant to treatment or mitigation and may require concentration followed by land filling or recycling [8].

Presently, some 2.4 billion people lack adequate sanitation and 3.4 million die each year in the world from water related diseases [9]. In most developing countries like Nigeria, most industries dispose their effluents without treatment. These industrial effluents have a hazard effect on water quality, habitat quality, and complex effects on flowing waters [10]. Industrial wastes and emission contain toxic and hazardous substances, most of which are detrimental to human health [11, 12]. The presence of heavy metals in the environment is a potential problem to soil and water quality due to their high toxicity to plants, animals and human life [13]. Heavy metals have been reported to be carcinogenic [14]; apart from being hazardous to living organisms when specific limits are exceeded, they also have accumulating tendencies, unlike organic pollutants that can be degraded chemically or biodegraded [15,16,17]. Recently, water and wastewater (effluents) contamination by toxic metals has become a global environmental concern [18] because of consequent interference with many beneficial uses of water [19]. This has led to the enactment of laws worldwide setting discharge limits of these metals from industrial effluents [20, 21]. In Nigeria, main contributors to the surface and ground water pollution are the byproducts of various industries such as textile, metal, dying chemicals, fertilizers, pesticides, cement, petrochemical, energy and power, leather, sugar processing, construction, steel, engineering, food processing, mining and others. As industrialization begins to take shape in Minna, Niger State due to stable power supply environmental pollution is getting more alarming. This paper therefore is aimed at determining the level of some heavy metal pollutant from pharmaceutical industrial effluent in Minna, Niger State Nigeria.

MATERIALS AND METHODS

Sampling Area

Samples were collected from pharmaceutical company in Miatumbi industrial layout Minna and surface water from River Gorax which is about 160meters from the industrial site. River Gorax is geographical located between latitude 9^0 31^0 N and longitude 7^0 0^0 E in Chanchaga, Minna. Wastewater and surface water Samples were collected from Miatumbi industrial layout and River Gorax in Minna, the samples were collected in cleaned, dry polyethylene bottles which have been previously washed with 20% nitric acid and subsequently with demineralized water. The samples were collected from eight points designated as S_1 to S_8, point S_1 was at the point of discharge of waste water in to the drain, S_2 was 50 meters from point S_1, S_3 was 100 meters from point S_1, and S_4 was the point of discharge of waste water in to River Gorax. S_5 was 100 meters up the river away from the point of discharge in to the river to serve as control. Point S_6 was the sample collected 200 meters down the river from point S_4 which is the point of discharge in to the River; S_7 was 400 meters from point S_4, while point S_8 was 600 meters from point S_4. Samples collected were taken to the laboratory and were refrigerated at 4^oC prior to analysis. Sampling and analysis of each parameter was conducted for three months from September to November 2012.

Laboratory Analysis

Samples collected were digested using HNO_3, the volume was adjusted to $100cm^3$ with distilled water [22]. Determination of the metals; Fe, Zn, Cu, Co, Mn, Cd, As, Ni and Pb was done using Perkin-Elmer Analyst 300 Atomic Absorption Spectroscopy (AAS).

RESULT AND DISCUSSION

Table 1: showed the variation of the heavy metals analysed in the samples from Maitumbi pharmaceutical industrial layout and River Gorax in Minna. The elemental concentration in wastewater and surface water samples showed highest mean concentrations at point S_1 for all the metals tested. This can be attributed to the fact that the effluent was highly contaminated as compared to the rest of the sampling points. The level of the contaminants was observed to decrease from point S_1 to S_4 in the drain and from S_6 to S_8 down the stream due to dillution, the mean concentrations were observed to be higher than the values obtained from the control at points S_5 for all the metals. For instance, the metal concentrations ranged from 9.28 to 1.08 mg/l for Fe; 2.25 to 0.05 mg/l for Zn; 0.15 to 0.02 mg/l for Cu; 0.00 to 0.08 mg/l for Co; 1.20 to 0.44 mg/l for Mn; 0.06 to 0.01 mg/l for Cd; 0.22 to 0.03 mg/l for Ni and 0.09 to 0.01 mg/l for Pb. The concentrations of heavy

metals in the Maitumbi industrial wastewater channel and River Gorax are in the following order Fe > Zn > Mn > Ni > Cu> Pb > Cd > Co. The concentrations of all the metals analysed were found above permissible limits by NSDWQ, WHO and FEPA for wastewater discharged in to surface water. These metals tend to bioaccumulate and are stored faster than excreted [23,24,25]. The increased use of these metals in the process industries has resulted in the generation of large quantities of aqueous effluents that contain high levels of heavy metals [26]. Although industrialization is inevitable, various devastating ecological and human disasters which have continuously occurred over the last four decades, implicate industries as major contributors to environmental degradation and pollution problems of various magnitude [26,27]. Some trace metals are potentially toxic because they act on the cell membrane or interfere with cytoplasmic or nuclear functions after entry into the cell. Hence, their accumulation in the human body could result to malfunctioning of organs [28]. Lead (Pb) for example, Lead (II) poisoning in human causes severe damage to kidney, nervous system, reproductive system, liver and brain. Severe exposure to lead has been associated with sterility, abortion, still births and neo-natal deaths [29,30]. Exposure to high lead levels can severely damage the brain and kidneys and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. High level exposure in men can damage the organs responsible for sperm production [31]. Cadmium exposure, during human pregnancy, leads to reduced birth weights and premature birth [32]. Long-term exposure to lower levels leads to a buildup in the kidneys and possible kidney disease, lung damage, and fragile bones [33]. Nickel binds to DNA in different positions. It binds to phosphate backbone of DNA in place of Mg and promotes the conversion of suppressor genes to the heterochromatin [34]. Moreover, it's binding to histone H4 leads to the inhibition of lysine acetylation, and subsequently DNA hypermethylation [35].

Table 1: Concentration (mg/l) of the Heavy Metals in Pharmaceutical Effluent and surface water samples from River Gorax, Maitumbi industrial layout, Minna, Niger State, Nigeria

Elements / SP	Fe	Zn	Cu	Co	Mn	Cd	Ni	Pb
S1	9.28 ±0.34	2.25 ±0.02	0.15 ±0.30	ND	1.20 ±0.10	0.06 ±0.02	0.22 ±0.12	0.09 ±0.01
S2	7.59 ±1.52	0.34 ±0.21	0.11 ±0.14	ND	1.10 ±0.09	0.01 ±0.01	0.15 ±0.13	0.05 ±0.08
S3	6.79 ±0.50	0.21 ± 0.02	0.04 ±0.03	ND	1.09 ±0.08	ND	0.10 ±0.10	0.01 ±0.01
S4	3.91 ±0.28	0.12 ±0.03	0.04 ±0.03	ND	0.62 ±0.05	ND	0.07 ±0.09	0.01 ±0.02
S5	2.43 ±0.08	0.05 ±0.02	0.02 ±0.01	ND	0.44 ±0.03	ND	0.03 ±0.02	ND
S6	1.72 ±1.90	0.18 ±0.16	0.37 ±0.01	ND	0.87 ±0.10	ND	0.13 ±0.09	0.07 ±0.02
S7	1.70 ±0.09	0.16 ±0.02	0.03 ±0.06	ND	0.72 ±0.02	ND	0.08 ±0.06	0.01 ±0.01
S8	1.08 ±0.13	0.16 ±0.21	0.02 ±0.02	0.08 ±0.01	0.59 ±0.05	ND	0.06 ±0.08	ND

All the mean in a row are statistically not significant at $P<0.05$

S_1 = point of discharge of waste water in to the drain, S_2 = 50m from point S_1, S_3 = 100m from S_1, and S_4 = the point of discharge of waste water in to River Gorax. S_5 = control 100m up the river. S_6 = 200m down the river from S_4, S_7 = 400m from S_4, S_8 = 600m from S_4

Table 2: Some selected Standard of the Heavy Metals worldwide(mg/l)

	Fe	Zn	Cu	Co	Mn	Cd	Ni	Pb
WHO	1.0	<1	0.05	0.02	0.05	0.03	0.02	0.05
FEPA	5.0	<1	0.01	0.02	0.05	0.05	0.05	0.02
NSDWQ	0.3	<1	1.0	0.02	0.2	0.03	0.02	0.01

FEPA [37]. WHO [38] And NSDWQ [36].

CONCLUSION

The results of this study revealed a high presence of heavy metals above the standard limits set by WHO, FEPA and NSDWQ for wastewater discharged in to surface water. The downstream points were observed to be more contaminated than the upstream point (the control). This indicates that there is unregulated discharge of contaminated effluent into the natural receptor - River Gorax without proper treatment by the industries. This may pose adverse consequences on health hazard and damage to the entire environment in general. It is therefore imperative for the government to enforce effluent treatment law to all pharmaceutical industries to reduce environmental and health risks.

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