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SCREENING OF MUNICIPAL EFFLUENT FOR HEAVY METALS: A CASE OF KUMASI

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ABSTRACT--

This research aimed to assess heavy metals concentration, Electrical conductivity, and pH of River Wewe, Asafo-fittamu drainage, and Suame Magazine. The water samples were collected from Wewe, Asafo-fittamu, and Suame effluents at Kumasi in the Ashanti Region of Ghana in February. The samples were analyzed for Cu, Pb, Cr, and Cd, using Atomic Absorption Spectrometer (AAS). Electrical conductivity and pH were analyzed using electrical meter and pH meter respectively. The results of this study showed that there were signs that there were significant differences in concentrations of the metals in the effluents. The higher concentrations of heavy metals in the effluents may be due to the activities around such effluents. The mean concentration of heavy metals (mg/L) in the Asafo-fittamu effluents, 0.920 for copper, 0.945 for lead, 0.503 for chromium, and 0.101 for cadmium. The mean concentration of heavy metals (mg/L) in Suame Magazine effluents, 1.413 for copper, 1.141 for lead, 0.063 for chromium, and 0.093 for cadmium. Wewe river being the control study recorded mean concentrations (mg/L) of heavy metals, 0.442 for copper, 0.553 for lead, 0.051 for chromium, and 0.099 cadmium. pH means concentrations for Asafo-fittamu, Suame, and Wewe were 6.067, 6.173, and 6.586 respectively. Electrical conductivity means concentrations for Asafo-fittamu, Suame, and Wewe were 1673.333, 1623.333, and 390.000 respectively. Heavy metals concentration in Asafo-fittamu and Suame Magazine were significantly higher than that of the Wewe River. Care must be taken to reduce the number of pollutants released into the effluents to prevent the future increase in heavy metals concentration in the effluents so that its concentrations would not exceed the national and international standards. --

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

Among all the pollutants, heavy metals have received paramount attention to environmental chemists due to their toxic nature. The main sources of heavy metals pollution in effluents are as a result of anthropogenic activities. Heavy metals are usually present in trace amounts in natural waters but many of them are toxic even at very low concentrations. Wastewater is used water, comprising of substances such as human waste, food scraps, oils, soaps, chemicals, domestic wastes. Businesses and industries also contribute their share of used water/wastewaters in addition to storm runoff burdened with harmful substances via runoff from roads, parking lots, and rooftops and this can harm our freshwater systems. Over the years, the Ashanti Region has experienced a high economic activity in the central areas like Kumasi. Migration and population increase being the predominant factor contributing to the activities in the Kumasi Metropolis. Suame Magazine lies on the side and bottom of a hill to the east of the main road to the northern regions of Ghana, and the west of a creek. The trapezoidal-shaped area is nearly 1.80 kilometers long with an average width of 320 meters(Obeng, 2015). Suame Magazine is known as a hub for automobile spare parts, automobile engineering, and industrial parts. The unique feature of the micro and small enterprises (MSEs) of Suame Magazine and their contribution to the national economy in the areas of engineering, industry, and agriculture, have extended their fame beyond the borders of Ghana. Neighboring countries namely: Burkina Faso, Togo, Mali, and Ivory Coast benefit from a range of engineering services in the maintenance and repair of vehicles, engineering manufacture of agro-processing machinery, and agricultural implements like hoes, shepherd crooks, bullock plow blades(Obeng, 2015).

Pollution has become a matter of concern as a result of the increased activities and toxic metals are of major concern among the pollutants. Some metals are essential such as copper, zinc, etc. because they play a role in biological systems, and cadmium, lead, etc. are also non-essential metals, as they become toxic in trace quantities. It is therefore essential to quantify the concentrations of Lead, Copper, Iron, Cadmium, and Chromium in effluents from these areas so appropriate environmental policies can be formulated to monitor their use and release into the environment.

1.2 PROBLEM STATEMENT

Due to the vital role of water for humanity, it is necessary to improve and maintain its quality. Environmental and global changes especially industrial wastes and domestic and agricultural activities are the main water pollution source. In the past, very little financial resources have been allocated for wastewater because water supply received more priority than wastewater treatment but because of the increasing rapid population growth and trends in urbanization, wastewater treatment plays an important role in human life.

Recently, because of the impact of sewage contamination of groundwater, rivers, and lakes, the growing awareness of wastewater is now receiving greater attention from environmentalists and researchers. Contaminants in wastewater include organic matter, metals, pathogenic microbes, biodegradable dissolved organic matter, and suspended solids. Heavy metals are better defined for the content of this discussion as toxic metals. Technically, heavy metals are defined as any metal having a specific gravity greater than 5.0.

However, not all heavy metals are toxic. Some of the most common toxic metals are lead, mercury, cadmium, copper, and chromium. Other heavier metals that have noted levels of toxicity are zinc, iron, and copper, it is important to note that many of these metals are already in the human body in trace amounts and are already in the human body in trace amounts and are essential for survival.

The industrial revolution followed by the advances in information technology during the last century has radically changed people's lifestyles. But mismanagement has led to new problems of contamination and pollution. Intake of heavy metals- contaminated vegetables can also pose a risk to human health. This because heavy metals can accumulate in living organisms and can be toxic at elevated levels.

1.3 JUSTIFICATION OF THE STUDY

Water is an important component of living organisms. It forms about 90% of the body fluid. Chemical pollution on its own is directly associated with heavy metal pollution and may adversely affect the physical, chemical, and biological characteristics of water. Activities around Suame magazine, Atonsu, and KNUST hospital and municipal runoffs are likely to deposit heavy metals into their effluents. To formulate laws that safeguard human health and the environment, the study seeks to help individuals understand the sources and quantities of various pollutants in the environment.

1.4 MAIN OBJECTIVE OF STUDY

The main objective of this research is to quantify heavy concentrations in effluents the municipal.

1.5 OTHER SPECIFIC OBJECTIVE OF STUDY

i. To determine the concentration of heavy metals in municipal effluent in Kumasi
ii. To ascertain the relationship between physicochemical properties (pH and EC) and heavy metal concentration in Municipal effluent in Kumasi.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ENVIRONMENTAL POLLUTION

The presence of heavy metals in water is due to both natural and anthropogenic sources. Natural sources may include parent rocks and metallic ores and, on the other hand, agriculture (fertilizers, animal manures, pesticides), metallurgy (mining, smelting, metal finishing), energy production (leaded gasoline, battery manufacture, power plants), microelectronics, sewage sludge, and scrap disposal can be included in the anthropogenic sources. (*Heavy Metals in Water*, n.d.). Pollution from man-made sources can easily create local conditions of elevated metal presence, which could lead to disastrous effects on animals and humans. Man's exploitation of the world's mineral resources and his technological activities tend to unearth, dislodge, and disperse chemicals and particularly metallic elements, which have recently been brought into the environment in unprecedented quantities and concentrations and at extreme rates. (Group, 2009). Due to the constant technological progress, the natural environment undergoes numerous changes, deteriorating its quality, which often results in negative interactions between particular ecosystem components.

2.2 HEAVY METALS AS ENVIRONMENTAL POLLUTANTS

Heavy metals are applied to any metallic element with relatively high density and at low concentrations is toxic or poisonous. Heavy metals are frequently given to embrace a diverse range of elements which form significant order of pollutant. Such pollutants have majority attention because of their serious harmful effect on living beings(Essumang, Aheto, & Debrah, 2011).

In recent years, heavy metals pollution has become one of the most serious environmental problems. Even traces of present heavy metal are toxic and harmful to both living and non-living things. With the swift development of industries, energy and wastes containing metals are discharged into the environment directly or indirectly leading to adverse pollution and threat to human life in the environment(Desanto & Editor, n.d.). Heavy metals in wastewater found their way to surface and groundwater, after entering into the aquatic environment it accumulates into the organs and tissues of aquatic creatures. The assimilation by aquatic organism enters into the food chain and consumed finally by humans(Agbozu, Ekweozor, & Opuene, 2007). Heavy metals are harmful to human health, aquatic organisms, and plants because they are not biodegradable while in small quantities, some heavy metals are nutritionally essential to human life. By processing of chemical weathering of minerals and soil leachate, metals form part the earth crust which is available in the environment. Children who come in contact with soil can develop toxic levels from hand to mouth activity.

2.2.1 LEAD (Pb)

Lead is a metal belonging to group IV and period 6 of the periodic table with atomic number 82, atomic mass 207.2, density 11.4gcm^{-3}, melting point 327.4C, and boiling point 1725C. it is a naturally occurring, the bluish-gray metal usually found as a mineral combined with other elements such as Sulphur or oxygen and ranges from 10 to 30mgkg^{-1} in the earth's crust(Wuana & Okieimen, 2011). Human activities are the main sources of lead, fossil fuel burning, mining, and manufacturing. Lead has many diverse uses, the production of batteries, ammunition, metal products, and devices to shield X-rays(Muhammad et al., 2014). In respect of how one is exposed to lead, the effects are the same, lead affect almost every organ and system in your body. The nervous system is the most susceptible to lead the attack, both in adults and children. When there is long-term exposure, adults result in weakness in fingers, wrists, or ankles, and also blood pressure increases, especially in middle-aged and older people, and can cause anemia(Muhammad et al., 2014). Lead poisoning is most commonly caused by ingestion and inhalation of lead and leads compounds. Lead is not an important element. It is well known to be toxic and its effects have been more extensively reviewed than the effects of other trace metals(Wuana & Okieimen, 2011).

2.2.2 CADMIUM (Cd)

Cadmium is a trace, extremely toxic metal. In nature, it occurs in trace amounts and presents 0.00005% of the crust of the earth. Comparing cadmium to other heavy metals, it is an environmental pollutant. Cadmium can get into the body’s bloodstream through the absorption from the stomach after the ingestion of food and water and lung absorption from the lungs after inhalation(Podgaiskyte & Vaitiekūnas, 2010). Together with zinc, lead, and copper cadmium occurs naturally. Cadmium compounds are mostly used as a colour pigment, alloys for bearings, stabilizers in PVC products, and rechargeable nickel-cadmium batteries. Fertilizers containing phosphate produces cadmium as pollutant too(Järup, 2003). When cadmium fumes/particles are inhaled, it can be life-threatening and although acute pulmonary effects and deaths are uncommon sporadic cases still occurs.

2.2.3 COPPER (Cu)

Copper is considered as one of the most important metals in industries. Industries such as metal finishing, electroplating, plastics, and itching. In the human body, it is very essential because it enables the body to form a red blood cell. It also helps maintain healthy bones, blood vessels, nerves, and immune function. Moreover, copper is a very toxic metal even at low concentration and copper contaminated water must be treated before discharging into the environment(Al-saydeh, El-naas, & Zaidi, 2017). The world health organization indicates that copper ions content in drinking water should not exceed 2mg/L.

Copper is a naturally occurring element that can be found in oceans, lakes, and the earth's crust. In the Earth’s crust, they are present in a concentration of about 67 parts per million. While most mines operate with a copper concentration of between 0.2 and 0.8%. Copper is known to be one of the noble metals as silver and gold and can be found in nature in the elemental form. It has high thermal conductivity, high electrical conductivity and malleable, low corrosion, alloying ability, and aesthetically pleasing appearance. Natural and anthropogenic sources contribute copper to water. For example, natural weathering of soil, atmospheric deposition, and

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discharges from industry and waste treatment plants, and the major source is from land runoff through natural weathering.

2.2.4 CHROMIUM (Cr)

Chromium was discovered in the Siberian red lead ore in 1798 by the French chemist vauquelin (Shanker, Cervantes, Loza-tavera, & Avudainayagam, 2005). Chromium is widely used in many fields due to its useful properties. Chromium exists in the oxidative states of hexavalent chromium and trivalent chromium which have low mobility and solubility and also relatively stable(Electro-reduction, 2019). Chrome plating, industrial welding, leather tanning, and also anticorrosive in cooking systems(Tchounwou, Yedjou, Patlolla, & Sutton, 2014). When chromium accumulates in the soil, they reduce the quality of food and its abundance which leads to microorganism's activity(Kampichler, 2014). The matter of course with chromium ion is on kidney, liver, and respiratory organs which leads to allergic dermatitis in humans, ulceration of the skin for chronic and sub chronic exposure(Gupta & Ali, 2004).

2.3 SOURCES AND DISTRIBUTION OF HEAVY METALS IN THE ENVIRONMENT

Natural and human are the two main sources of heavy metals in wastewater. Soil erosion, volcanic activities, urban runoffs are natural factors whereas mines waste, electroplating processes, textile industries, and nuclear power are human factors(Akpor, Ohiobor, & Olaolu, 2014).
Soil erosion is known as one source of heavy metal pollution in water, wind, and water being the main agents. Sediments with heavy metals adsorbed to their surfaces are distributed during a downpour. Metal finishing, electroplating, mining, and extraction operations are some of the human sources of heavy metals in wastewater effluents.

2.4 TOXICITY AND HARMFUL PROPERTIES OF HEAVY METALS

At certain concentrations, heavy metals are toxic to higher organisms, microorganisms, and plants(Chipasa, 2003). Toxic metals are trace metals that are detrimental to human health, once released into water bodies(Muhammad et al., 2014).

2.5 THE TOXIC EFFECT OF HEAVY METALS

Heavy metals have become a threatening topic and come along with several health risks. The toxic effects of these metals even though they don't have any biological role interferes with the proper functioning of the human body. They function as a pseudo-element of the body but also disrupt the metabolic processes at certain times. Few elements, like aluminum, for instance, can be removed through elimination activities, while others get accumulated in the body and food chain exhibiting a chronic nature. Metal toxicity depends on the absorbed dose, the route of exposure, and duration of exposure which can lead to various disorders and can also result in excessive damage due to oxidative stress induced by free radical formation(Jaishankar, Tseten, Anbalagan, Mathew, & Beeregowda, 2014).
Heavy metals can have carcinogenic effects, for instance, the mechanism of the lead-induced carcinogenic process is postulated to induce DNA damage, disrupt DNA repair system, and cellular tumor regulatory genes through the generation of ROS. Also, the proposed mechanism of mercury-induced cancer is through the generation of free radicals inducing oxidative stress thereby damaging biomolecules. Mercury has been shown to induce malignant growth through the generation of free radicals as well as disruption of DNA molecular structure, the repair, and the maintenance system. Cadmium has been implicated in promoting apoptosis, oxidative stress, DNA methylation, and DNA damage(Godwill, Nwalo, & Unachukwu, 2019).
Heavy metals can enter the human system through the food chain. The uptake of heavy metals from soils at high concentrations may result in great health risks. Heavy metals become toxic when they are not metabolized and accumulate in the soft tissues. The chronic ingestion of these heavy metals has unfriendly impacts on humans and the harmful impacts become perceptible only after several years of exposure. Cadmium targets organs such as the liver, placenta, kidney, lungs, brain, and bones. Depending on the severity of exposure, the symptoms of effects include nausea, vomiting, abdominal cramps, dyspnea, and muscular weakness. Severe exposure may result in pulmonary edema and die. Zinc is considered non-toxic but when taken in high quantities can cause dysfunctions such as vomiting, diarrhea, bloody urine, icterus, liver failure, kidney failure anemia. Excessive human intake of Cu may lead to severe mucosal irritation and corrosion, widespread capillary damage, hepatic and renal damage, and central nervous system irritation followed by depression. Severe gastrointestinal irritation and possible necrotic changes in the liver and kidney can also occur. The effect of nickel exposure varies skin from skin irritation to damage to the lungs, nervous system, and mucous membranes. Lead may result in a dysfunction in the kidney, reproduction system, liver, and brain resulting in sickness and death. Also, lead causes inhibition of

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the synthesis of hemoglobin, cardiovascular system, and acute and chronic damage to the central nervous system and peripheral nervous system(Kampichler, 2014).

2.6 CONTAMINATIONS OF HEAVY METALS IN WATER

Increased in civilization and development have led to the direct impact of the environment. Worldwide, the aquatic system and other water bodies are polluted with several heavy metals through many activities resulted from the direct and indirect behaviors of humans(Siddiquee et al., 2015). The most serious water pollutions have occurred with some waterbodies such as lakes, oceans, streams, and groundwater. There are two types of water pollution, the point, and nonpoint sources.

The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. The nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification. Nonpoint source pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. Most of the water bodies in urban areas of the developing world are the endpoint of effluents discharged from the industries(Suthar, Nema, Chabukdhara, & Gupta, 2009). Surface water pollution has increased rapidly over the years attracting society's attention over the past decades. Aquatic systems are polluted with heavy metals either by natural or anthropogenic sources. Industrial effluents, the leading factor of heavy metals pollution. The unique properties of heavy metals help in the pollution of the water bodies, mainly that they are non-thermo-degradable, non-biodegradable(Mapanda, Mangwayana, Nyamangara, & Giller, 2005). Accumulation of these metals in wastewater depends on many common factors which include the type of industries in the region, peoples of life, and awareness of the impacts done to the environment by careless disposal of wastes(Chipasa, 2003).

2.7 HEAVY METALS IN MUNICIPAL WASTE

Heavy metal pollution has become a health effect in Ghana, especially residential and industrial areas as a result of poor zoning and mixed activities. The area popularly known in Kumasi engaged in mixed activities is Suame industrial, area which is usually known as "Suame Magazine" where car batteries are repaired, spraying of cars, metal fabrication workshops, and automobile workshops are located. The activities involved heavy metals and other industrial waste such as automobile oil and grease which poses a health risk on workers and inhabitants such as geo-accumulation(Acheampong, Akenten, Imoro, Agbesie, & Abaye, 2016). Discharge of untreated wastewater into waterbody can decrease oxygen concentration which might lead to septic conditions and could be hazardous to human health.

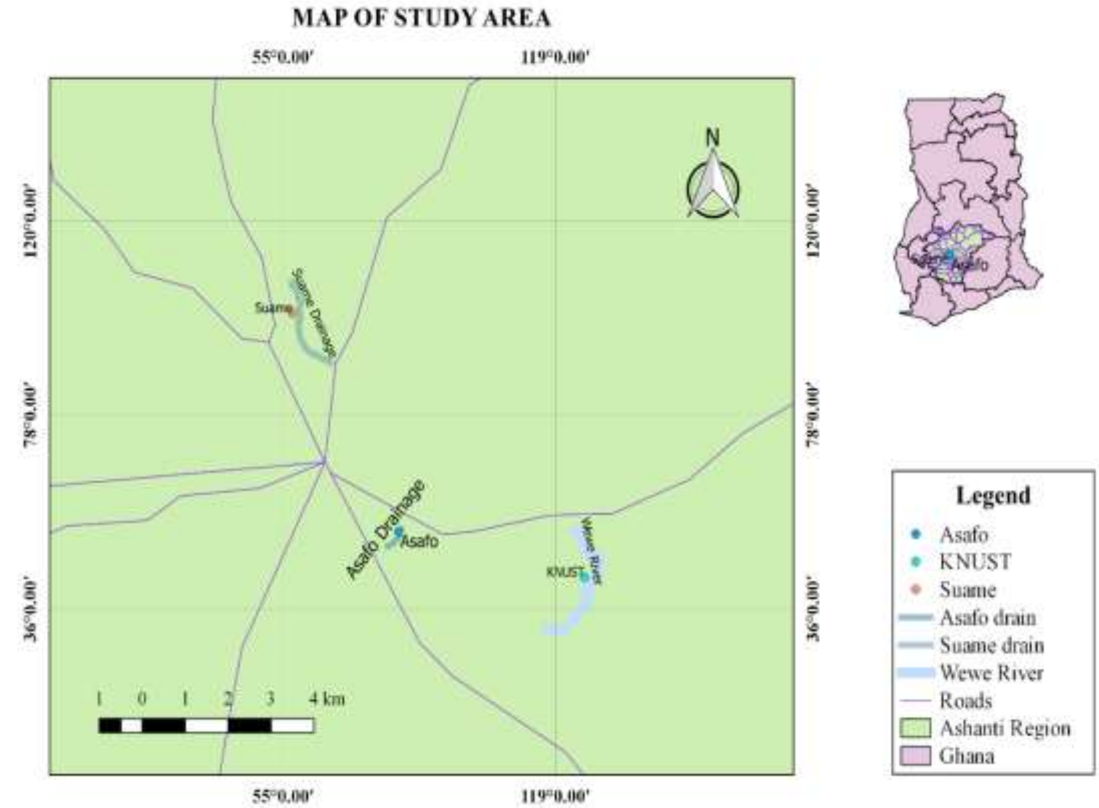
CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Kumasi, the capital city of the Ashanti Region was chosen for the study. There were three different sampling stations; Wewe river (KNUST), Asafo-fittamu, and Suame magazine shown in figure 3.1 below. In choosing the sampling stations, preference was given to factors such as wastes from the residence halls(sewage), domestic wastes, and industrialized and engineering activities spilling into effluent respectively.

Figure 3.1: Map showing the catchment areas of samples



Suame Magazine is located in the Suame constituency, 10km from Kumasi, the capital town in the Ashanti Region, its rest on a hill, latitude N06°43.623' and longitude W001°37.770' are the coordinates (GPS essential). The area sees many forms of industrial use such as auto mechanic shops, car body parts repairs, metal fabrication workshops (smelting, welding, and molding), manufacturing of aluminum silver utensils, it can be considered the most industrialized zones in Ghana and one of the largest in Africa. The area is not well demarcated due to the haphazard shops built on the land area. Suame is also known for vigorous commercial activities including automobile spare parts and building materials.

About 50metres from Japan motors (a building that serves as a garage for some workshops) is a drainage system where wastewater from the Suame Magazine passes through to Maakro and it is polluted by plastic containers, drinks, and sachet water packages to mention a few. Also, around the drainage are workshops and trees. The wastewater looked blackish with a slow runoff. According to the residents, this is the main drainage system in the area as well as the dumping site for other drainage channels.

Asafo-Fitamu is a suburb of Kumasi in the Ashanti Region of Ghana. It can be located on the Kwaku Atakora street, Kumasi. The area is characterized by buildings that serve as homes for residents and others used as stores where a variety of products are sold. On the Kwaku Atakora street, a large portion of the landscape is used as an automobile fitting area where cars are parked, others abandoned and some undergoing maintenance. There is a blackish soil around these areas due to the spillage from grease, oil and petroleum products. Wastewater samples were taken from an open drainage system found between an aluminum and working site and a car fitting shop. The area is located on longitude W001°36.534' and latitude N06°41.086', it is open drainage with free-flowing parts and stagnated parts as a result of the presence of plastic wastes and large concrete stones in it. The effluent was generally black.

The wewe river, an inland water body in Kumasi in the Ashanti Region of Ghana, takes its source from mountains near Aboabo Nkwanta and flows for about 13miles southwest towards Abirem and Weweso, it passes through the Kwame Nkrumah University of Science and Technology campus to join River Ahinsa. The point of sampling was at the Mecca road, beneath a bridge, the latitude N06°43.623' and longitude W001°37.770'. The KNUST residence discharges their wastewater and other sewages into the river that passes through its environs, wastes from the residence halls, canteens, and laboratories are deposited directly into the river. With the rapid flow of the river, there is much assimilation and discharge of the wastes deposited making it clear and less polluted. The river supports life as fishes and other aquatic organisms are found in it. This river serves various purposes including recreational and agricultural activities and a source of household water, in the several communities it passed through along its course.

3.2. Sample collection

There were three different sampling stations; Wewe river (KNUST), Asafo-fittamu, and Suame magazine shown in figure 3.1 above. In choosing the sampling stations, preference was given to factors such as wastes from the residence halls(sewage), domestic wastes, and industrialized and engineering activities spilling into effluent respectively. Sampling was done at one point in the flowing effluent in February 2020. The grab sampling method was used. It was performed wearing a rubber glove. Three 500ml bottles labeled as PH., EC (electrical conductivity), and toxic metals for three other bottles. The grab sampling was done using a bowl with a handle. The bottles were rinsed three times using the wastewater before filling the bottle a little bit to the brim. The collected water was acidified using 1ml of concentrated nitric acid and further kept in an iced-chest before transported to the laboratory for analysis.

3.3 Laboratory Procedures

All laboratory analysis was performed at the soil science laboratory at the faculty of Agriculture in Kwame Nkrumah University of Science and Technology, Kumasi. Physiochemical parameters were measured in the water samples from the sampling bottles labeled pH. and EC which had no nitric acid added to it. The other three samples were analyzed using the flame atomic Absorption Spectroscopy. The chemicals used were

I. Concentrated Nitric Acid
II. Concentrated Hydrochloric Acid

3.3.1 Analysis of Samples

The physiochemical parameters were measured within twelve hours after samples were taken, whereas the acidified samples were refrigerated and analyzed after 72 hours of sampling. pH and Electric conductivity were measured using a pH. meter and electric meter conductivity respectively. About 25ml of the sample was poured into a beaker and the EC meter inserted into the beaker containing the sample. Readings were displayed and recorded from the screen.

3.3.2 Apparatus and Reagents used

i. 18 500ml bottled water containers
ii. Concentrated nitric acid
iii. Hydrochloric acid
iv. 5ml measuring cylinder
v. Beaker
vi. Iced-chest
vii. Conical flask
viii. Latex hand gloves
ix. Sampling plastic bottles
x. Volumetric flask
xi. Sample collector

3.4 Digestion of Samples

Acidified samples were removed from the refrigerator and 50 ml of the sample poured into a measuring cylinder and transferred into a conical flask. 10 ml of 5%concentrated nitric acids were further added before 30 ml of hydrochloric acid finally added to the sample. The mixture was done in the Kjeldahl room in the laboratory. A steady heat was applied (at a temperature of 450°C) to the mixture for 30 minutes to 60 minutes till the mixture changes to a whitish color indicating completion of digestion. The resulting mixture was transferred into a 100 ml conical flask with distilled water added to reach the 100 ml mark. The diluted solution was transferred into a plastic bottle for analysis using the Flame Atomic Absorption Spectroscopy.

3.5 Atomic absorption spectroscopy (Instrumentation)

The digested samples were distributed into well-labeled bottles and sent for Atomic Absorption Spectroscopy (AAS). The basic setup (air pressure = 50 – 60 psi, acetylene pressure = 10- 15 psi and voltage = 208 – 240 V) of

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the AAS was ensured. Calibrations were made with a standard solution of respective metals and de-ionized with distilled water before used to measure levels of metals in digested samples. The file for the type of analysis and hollow cathode lamps were selected with appropriate wavelengths- Cu at 324.8 nm, Pb at 217.0 nm, Cd at 228.8 nm, and Cr at 582.0 nm. The flame atomizer was turned on and the intense heat breaks up the sample solution into individual atoms.

3.6 Statistical Procedure
Metal concentrations among individual samples were analyzed using IBM SPSS Statistics 20. The data obtained from the laboratory were entered into the SPSS software, cleaned and edited before analysis. The analysis involved both descriptive statistics and inferential statistics. The descriptive statistics which include measures of central tendencies (mainly the mean) and dispersion (standard deviation) were used to describe and summarized the level of concentration of heavy metals and the physicochemical properties of the water samples from the three sampling areas. The inferential statistics used was the analysis of variance (One-way ANOVA) to compare the mean levels of the various heavy metals and physicochemical properties across the 3 sampling locations.

CHAPTER FOUR
4.0 RESULTS AND DISCUSSIONS
4.1 RESULTS
4.1.1 Physicochemical Parameters of the Water
The physicochemical parameters of samples collected from the three sampling locations over the study period are presented below (Table 4.1). Using Wewe River as our control site for monitoring the conductivity levels in the wastewater sampled, the average conductivity for Wewe was 390 µs/cm a whereas the conductivity for Suame Magazine and Asafo-Fitamu was 1623.33 µs/cm and 1673.33 µs/cm respectively.

pH for the Suame Magazine sampling site as of February 2020 was averaged 6.17. electrical conductivity from the table was 1623.33. Results obtained for electrical conductivity from the laboratory indicated a range between 1620 and 1650 µs/cm with an average of 1623.33.

The average pH recorded from the sampling site was similar to the values recorded at Suame and Wewe river over the period where sampling was done in February 2020. The average pH value recorded was 6.06. Conductivity values were slightly higher compared to conductivity values obtained from Suame Magazine. The values ranged between 1640 and 1720 µs/cm with an average of 1673.33 µs/cm.

Wewe River, used as the control for the experiment had a pH value similar to the pH values recorded at Asafo-fittamu and Suame Magazine. From the table, it had an average pH value of 6.58. However, conductivity values obtained from the sampling site at the time of sampling were low. Conductivity values were ranging between 380 and 400 µs/cm.

Table 4.1 Physicochemical Parameters of the water samples from the three sampling locations.

	LOCATIONS		
	Asafo Fittamu	**Suame Magazine**	**Wewe River (control)**
Parameter	Mean ± SD	Mean ± SD	Mean ± SD
pH	6.067±0.351	6.173±0.087	6.586±0.089
EC (µs/cm)	1673.333±41.663	1623.333±15.275	390.000±10.000

4.1.2 Comparison of Metal Concentration in Water
In general, mean concentrations of chromium in Asafo-fittamu, Suame, and Wewe varied significantly. Mean chromium concentrations in Asafo-fittamu, suame and wewe were 0.050 mg/L, 0.63 mg/L and 0.037 mg/L respectively. Relatively higher concentrations of chromium were recorded in Asafo-fittamu, and suame than that of wewe(control), suame being the highest. Also, significant differences ($p<0.05$) were recorded for the overall metal concentrations in the Asafo-fittamu, Suame, and Wewe respectively.

Cadmium concentration in water at Asafo-fittamu sampling is the highest with mean values of 0.101 mg/L, wewe (control) recorded 0.093 mg/L and Suame recording 0.098 mg/L. Overall there were significant differences($P<0.05$) in cadmium concentrations recorded at three sampling stations.
According to laboratory results obtained from the analysis of Copper (Cu), the mean concentration of Copper in effluents from Suame Magazine was higher than the corresponding mean concentrations from Asafo and Wewe

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River which were found to be 0.920 and 0.442 mg L^{-1} respectively. Overall, there was a significant difference ($p<0.05$) in the concentration of copper across the three sampling locations.

The outcome of the various sample analyzed in the laboratory, the average of Asafo-fittamu is 0.945 while Suame recorded 1.141 and Wewe 0.553 which indicates the difference in mean at the various stations given. The average significant value is 0.05 since the significant value is smaller than the various station's values. This indicates differences in concentration in various stations.

Table 4.1.2 Physicochemical Parameters of the water samples from the three sampling locations.

	LOCATIONS		
	Asafo Fittamu	**Suame Magazine**	**Wewe River**
Parameter/ mg/L	Mean ± SD	Mean ± SD	Mean ± SD
Copper (Cu)	0.920±0.094	1.413±0.097	0.442±0.029
Lead (Pb)	0.945±0.059	1.141±0.021	0.553±0.008
Chromium (Cr)	0.503±0.005	0.063±0.003	0.051±0.012
Cadmium (Cd)	0.101±0.213	0.093±0.032	0.099±0.013

4.2 DISCUSSION

4.2.1 Concentration of heavy metals and chemical parameters in suame magazine.

The results of this study show that there is a higher concentration of metals in Suame magazine as compared to the other sites studied and that may be due to the activities that take place at Suame magazine and dumping of waste into the stream. There was a higher concentration in copper, cadmium, lead, and chromium in Suame magazine waste effluent that was tested and may be due to the domestic wastes, urban storm-water runoffs such as car batteries, and other automobile wastes. The pH that was tested in the laboratory, the last sample for Suame magazine is more acidic and the low pH caused by nitrification in combination with low natural alkalinity in the wastewater. According to (Akoto, Bruce, & Darko, 2008), electrical conductivity is the numerical expression of an aqueous solution to carry electrical current and is a useful indicator of the mineralization in a water sample. Copper has the highest electrical conductivity in Suame magazine and has the ability of a material to carry the flow of an electric current.

4.2.2 Concentration of heavy metals in the Wewe river.

Wewe river was selected as one of our areas of study. our motive for conducting this experiment was to account for the concentration of some heavy metals such as lead, copper, cadmium, and chromium. PH and electrical conductivity are physiochemical parameters to be noted in this experiment. The concentrations of these heavy metals may be due to farming, dumping of waste or wastes from laundry and cars around the area. Surface runoff water through the gutters constructed into the river may also have contributed to the presence of heavy metals could be the activities that go on around the water areas and even in the water. As these activities generate all the heavy metals they somehow find their way into the water directly or indirectly(*Journal of Chemical and Pharmaceutical Research, 2015, 7 (12): 700-705 Review Article*, 2015) believes industrial activities, agricultural activities, and domestic activities could account for the presence of heavy metals in water. A similar study case of the Tembi River in Nigeria reveals the presence of heavy metals in the river(Shanbehzadeh, Dastjerdi, Hassanzadeh, & Kiyanizadeh, 2014). In similar research, Wogu and Okaka investigated nine similar metals in the Warri River in Nigeria, which received industrial, agricultural and urban sewage.

Experimental results showed that heavy metal concentrations found in effluents from Asafo Fitamu varied in concentration. Results showed that the mean concentration of Copper, Lead, Cadmium, and Chromium were 0.920 mg\L,0.944 mg\L,0.101 mg\L, and 0.050 mg\L respectively. The concentration of Cadmium was the highest compared to the concentrations found on Suame and Wewe. This heavy metal concentration showed a significant difference in concentration ($p>0.05$). Cadmium serves as the main constituent for automobile batteries and used in the making of car paints. Also, the point of sampling serves as the main waste discharge point for most of the automobile repair shops around. The values for Electrical conductivity obtained from laboratory analysis showed a range between 1640 and 1720 µs/cm with an average of 1673.33 µs/cm. A higher electrical conductivity is an indicator of the presence of salts in the water sample and hence can conduct electricity.

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This research indicates that there is a high concentration of Copper, Lead, Cadmium, and Chromium in wastewater effluents from "Suame Magazine". Results also indicated a high level of these metals in the effluents sampled in Asafo-Fittamu with Wewe River having a low concentration of these metals. The analysis of the Physiochemical parameters of wastewater from these sampling sites showed a high Electrical conductivity value except for the effluents from Wewe. Averagely, the pH of the effluents was almost neutral.

5.2 RECOMMENDATIONS

From the results of this study, it is recommended that;

i. Further study should be conducted to assess the pollution of Asafo-fittamu by other heavy metals not considered in this study.
ii. There should be Public education by EPA and KMA to create awareness of the consequences of heavy metals accumulated in the Asafo-fittamu and Suame Magazine stream.
iii. Further study should be conducted on a relatively higher concentration of chromium recorded in Asafo-fittamu.
iv. The district assemblies should institute bye-laws to prevent people from discharging wastes, washing of cars, and dumping of refuse near or around the Asafo-fittamu and Suame Magazine stream.

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APPENDIX

SAMPLE NAME WATER SAMPLES	Cu(mg/L)	Cd(mg/L)	Pb(mg/L)	Cr(mg/L)	pH	EC(Us/cm)
ASAFO FITTAMU	1.025	0.1025	0.9973	0.0560	5.90	1660
ASAFO FITTAMU	0.890	0.1220	0.8812	0.0495	5.83	1640
ASAFO FITTAMU	0.845	0.0795	0.9558	0.0455	6.47	1720
SUAME MAGAZINE	1.525	0.0690	1.1216	0.0654	6.27	1640
SUAME MAGAZINE	1.345	0.0815	1.1382	0.0598	6.15	1620
SUAME MAGAZINE	1.370	0.1295	1.1630	0.0625	6.10	1610
WEWE RIVER	0.475	0.0880	0.5447	0.0598	6.69	380
WEWE RIVER	0.420	0.1135	0.5613	0.0555	6.54	390
WEWE RIVER	0.431	0.0945	0.5542	0.0364	6.53	400