

Effect of Selected Heavy Metals on Water Quality: A Case Study of Selected Water Springs in Makindye Division

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ABSTRACT

Heavy metal ions can be introduced into the water through several point and non-point sources including leather industry, coal mining, agriculture activity and domestic waste. Regrettably, these toxic heavy metals may pose a threat to both humans and animals, particularly when they infiltrate water and soil. Heavy metal poisoning can lead to many health complications, such as liver and renal dysfunction, dermatological difficulties, and potentially even malignancies. To mitigate the risk of heavy metal ion exposure to humans and animals, it is imperative to extract them from places that have been polluted. Several conventional methods such as ion exchange, reverse osmosis, ultrafiltration, membrane filtration and chemical precipitation have been used for the removal of heavy metal ions. However, these methods have high operation costs and generate secondary pollutants during water treatment. Bio sorption is an alternative approach to eliminating heavy metals from water that involves employing eco-friendly and cost-effective biomass. This review is focused on the heavy metal ions contamination in the water, bio sorption methods for heavy metal removal and mathematical modeling to explain the behavior of heavy metal adsorption. This research can be helpful to the researchers to design wastewater treatment plants for sustainable wastewater treatment.

Keywords: Heavy Metals, Water Quality, Springs and Makindye Division

INTRODUCTION

Poor water quality, concentrations and health risks of heavy metals in eight major lakes in Kenya namely Naivasha, Elementaita, Nakuru, Baringo, Bogoria, Turkana, Victoria and Magadi was a major problem faced by people in Kenya for quite longer period of time. Water quality was assessed using water quality index and pollution evaluation index, while human health risk associated with ingestion and dermal contact of heavy metals was assessed using hazard quotients and hazard index. Principal component analysis and hierarchical cluster analysis were used to deduce the probable sources of the heavy metals. The average concentration of aluminum, molybdenum, manganese, nickel, arsenic, zinc, selenium, lead, chromium, mercury, cobalt and cadmium in the eight lakes was 824.6, 66.1, 58.9, 16.2, 8.40, 7.84, 6.91, 4.65, 2.66, 0.86, 0.78 and 0.46(miligrams per liter), respectively, all in mercury, aluminum, manganese, arsenic, were relatively high in Rift Valley lakes and exceeded the maximum permissible levels for drinking water [1, 2]. Notably, high heavy metal

concentrations were recorded at the entry points of rivers and areas with high human activities. Lake Magadi had the highest average water quality index of 158.8 followed by Lake Elementaita (128.4), Bogoria (79.5), Nakuru (73.3), Turkana (57.6), Victoria (52.3), Baringo (42.6) and Naivasha (25.5). Lake Magadi also had the highest average PEI of 40.0 followed by Elementaita (30.1), Bogoria (16.2), Nakuru (15.7), Victoria (10.8), Baringo (9.57), Turkana (9.53) and Naivasha (5.12) [1]. Based on water quality index, Lake Naivasha water was excellent for drinking, Lake Victoria, Turkana, Baringo, Nakuru, and Bogoria had good water, but water from Lake Elementaita and Magadi was of poor quality. PEI classified the lakes as minimally polluted except Lake Magadi. Multivariate analysis concluded that lead, chromium, nickel and selenium had anthropogenic sources, mainly agricultural and urban runoff, but other HMs had natural influence. Although the HMs did not pose any health risks through dermal contact, Ingestion was >1 for adults

and children consuming water from Lake Elementaita, Nakuru, Bogoria and Magadi due to non-carcinogenic risks associated with As, Zn and Mo. These results are important for formulating the necessary remediation policies to improve water quality in the eight lakes [1]. Globally, different theories have tried to explain the effect of heavy metals on water quality and they include; Bioaccumulation theory[3, 4]: This theory suggests that heavy metals can accumulate in living organisms through various path ways, such as ingestion or absorption through the skin. Once in the body, these metals can bio accumulate, meaning they build up over time and can reach toxic levels. This process can occur in aquatic organisms like fish, which can then be consumed by humans, leading to potential health risks[5]. Toxicity theory: The toxicity theory posits that heavy metals exert their harmful effects on water quality due to their inherent toxic properties. These metals can disrupt biological processes in aquatic ecosystems leading to adverse effects on aquatic life and potentially impacting human health through the consumption of contaminated water or food sources [6]. Ecological risk assessment theory: This theory focuses on evaluating the potential risks posed by heavy metals contamination to aquatic systems and their inhabitant's. Ecological risk assessment considers factors such as the concentration of heavy metals present, exposure pathways and the sensitivity of different species to contamination [7].

In Africa: Various theories have been proposed to explain the relationship between heavy metals and water quality in Africa considering factors such as industrial activities, mining operations, agricultural practices, and natural geological processes. One of the primary theories linking heavy metals to water quality in Africa is the discharge of industrial effluents containing heavy metals into water bodies. Industries such as mining, manufacturing, and chemical processing often release wastes to the water contaminated with heavy metals like lead, mercury, cadmium and arsenic. These pollutants can leach into ground water sources or surface water bodies leading to contamination and degradation of water quality [8, 9]. Mining Operations: Mining activities in Africa are another significant source of heavy metal pollution in water systems. Mining operations for minerals like gold, copper, and uranium can release substantial amounts of heavy metals into the environment through hailing dams, waste rock piles and acid mine drainage. The runoff from their sites can contaminate nearby rivers, lakes and ground water reserves, posing risks to both human populations and aquatic ecosystems [9] In East Africa: The relationship between heavy metals and water quality has been a topic of concern due to its potential impact on human

health and the environment. Several theories have been proposed to explain the relationship, taking the account of various factors such as geological formations, industrial activities, agricultural practices and urbanization. One of the primary theories is that geological sources play a significant role in the presence of heavy metals in water bodies in east Africa. The regions geology characterized by volcanic activity and mineral deposits, can lead to the natural occurrence of heavy metals in the environment For example, Areas with high concentrations of minerals like gold, copper, and lead are more likely to have elevated levels of these metals in water sources [10, 11]. Industrial Pollution: Industrial activities including mining, manufacturing, and processing plants are major contributors to heavy metal contamination in water bodies. In East Africa, rapid industrialization has led to an increase in pollution from industries releasing heavy metals such as mercury, cadmium, and chromium into rivers and lakes. Improper disposal of industrial wastes containing heavy metals can result in long term water quality issues [12, 13]. In Uganda, different theories have tried to explain the relationship between heavy metals (lead, copper, mercury, arsenic, cadmium) and water quality in Maki dye division as below. Centers for disease control and prevention (CDC).the CDC offers information on health effects of lead exposure and recommendation for preventing exposure through drinking water [14]. World health organization(WHO), the WHO conducts research on the environmental health issues related to drinking water quality and provides global guidance on mitigating risks associated with contaminants like lead, copper, mercury, arsenic, and cadmium [15]. Water pollution due to heavy metal contamination in Maki dye division is a significant environmental concern that possess serious threat to living organisms. Heavy metals example lead, mercury, cadmium, arsenic, copper are highly toxic and have detrimental effects on both aquatic ecosystems and human health. These metals enter water sources through various pathways including industrial activities, mining operations, agricultural practices and urban runoff. Once in the water, heavy metals can accumulate in living organisms, leading to arrange of health issues and ecological imbalances. Efforts to mitigate heavy metal pollution in water include implementing strict regulations on industrial emissions and waste disposal practices, promoting sustainable agriculture to reduce pesticide and fertilizer run off, invest in waste water treatment technologies to remove heavy metals before discharge into water bodies and conducting regular monitoring of water quality to detect contamination early [16]. It's upon this back that this study will investigate the

effect of heavy metals on water quality in Makindye division. The study of the effect of heavy metals on water quality is justified due to several critical reasons. Determination of the sources of heavy metals; this study will help the citizens to know the different sources of heavy metals which will be the first step in controlling the effect caused by heavy metals. Environmental concerns. Heavy metal

pollution poses a significant threat to the environment as these elements can accumulate in soil and water bodies affecting plant life, aquatic ecosystems and overall biodiversity. After knowing the harmful effects of heavy metals, the people would know possible ways of controlling the effects caused by heavy metals on the environment.

Methodology

Research design

This study will be conducted through case study: Research design is intensive, descriptive, and holistic analysis of a single entity. It will be used by selecting a specific place in Makindye division and a sample of 20 water springs and water sources in Makindye

division near Mukwano industries and a sample population of 200 people who take water near the industry. The design was selected for this study because one of the major source of metals is the industrial activity which is common in industries.

Population

Target Population

This study will be conducted in a population of 200 people living near 20 different water springs and also far from the water springs that are polluted by metals from industries. This has been chosen because this population will enable reasonable number of people from far and near the water springs that are polluted by the industries to be examined from the effects of heavy metals. The population consists of both old and young people .the old and young people will be used

to determine the time the effect of heavy metals take to become toxic in the body. This can be done by comparing the time taken by an individual in a particular area and also the level of effect in one's body. The population will also consist of people who have leaved from different places .this is to compare the changes that they have experienced in different places in terms of water quality. This can be done through asking questions.

Sample

This has been procedurally selected to represent the whole population .In this study, five people will be selected to represent the rest. These five people should be of different categories.ie two people should have stayed from different places, one who is from an area where industries were not found and one should be from a place in which industries were concentrated. These two people will help provide answers to the questions trying to compare water quality of different places and also help the researcher to finally determine the sources of heavy metals. Also two people will be the ones that have stayed there from the start up to date and one of them should be young and one should be old. These two people will help the researcher to answer the question concerning time taken for the effect of heavy metals to be determined

by testing them on the effect of heavy metals and the one person should be the person who works in the industry and has experience in the industrial processes and waste disposal in the industry. This person will help the researcher assess the toxic effect of heavy metals on water quality and also provide the source of heavy metals. Out of these five people, three of them should be depending on the water springs near the industry and two of them should be depending on water sources far away from the industries. The five respondents from each area will be distributed as; two from Mukwano industrial area, and three from Namwongo industrial area. This has been chosen according number of people complaining of poor water quality in these two areas.

Sampling Technique

This is the description of the strategies which the researcher will use to select representative element from the target population. This study will employ stratified sampling .Stratified sampling technique will be used to select the areas of suspected poor water quality due to accumulation of heavy metals .stratified sampling technique is a technique that identifies sub groups in the population and their proportions and selected from each sub group to form a sample[17] .It groups a population into separate homogeneous subsets that share similar characteristics and selects

from each sub group so as to ensure equitable representation of the population in the sample .It aims at proportionate representation with a view of accounting for the difference in sub groups characteristics. The target population is not uniform, this is because different places may have different levels of contamination by heavy metals since the rate of reaction by different heavy metals differs from each other. Stratified sampling technique will therefore be used to ensure that the target population is divided into different homogenous strata and that each

subgroup (strata) is represented in the sample in a proportion equivalent to its size in the population. This will ensure that each subgroup characteristics is

represented in the sample thus raising the external validity of the study.

Data collection Instruments

This refers to the tools to be used for collecting data and how these tools were developed. In this study, questionnaires, and observation techniques were used as the main tools for collecting data. The selection of these tools was guided by the nature of data to be

collected, the time available as well as by the objectives of the study. The overall aim of this study was to determine the effect of heavy metals on water quality.

Research procedure

This section describes how the data will be collected by using the instruments described above. The researcher will develop a proposal over a period of about two weeks under the guidance of the supervisor. Once the proposal is ready, the researcher will seek permission from the University to proceed with the study. Once the permission is granted, the researcher will proceed to collect data .Data concerning sources of heavy metals and water quality

will be collected from 100 respondents from target population of 200 respondents during a period of one month. Using questionnaires and observation techniques. The data will be collected by the field assistants because he has experience and have seen the toxic effects of heavy metals on water quality. The data collected will be analyzed through inferential analysis (ANOVA F-test) and represented in tables and figures.

Quality control

Controlling quality is about ensuring acceptable levels of validity and reliability of the study through proper control of extraneous variables. The instrument will be piloted in the industrial areas which will not be included in the study sample and modified to improve their validity and reliability coefficients of 0.70 .Validity is the extent to which research results can be accurately interpreted and generalized to other populations .It is the extent to which research instruments measure what they are

intended to measure (Knapp & Mueller, 2010).to establish validity ,research will be given to two experts to evaluate the relevance of each item in the instrument to the objectives and rate each item on the scale of very relevant (4),quite relevant(3),somewhat relevant(2) and not relevant (1).Validity will be determined using content validity index (C.V.I).C.V.I=items rated 3or4 by both judges divided by the total numbers of items in the questionnaire.

Data Analysis

This section of the proposal deals with organization, interpretation and presentation of the collected data. In this study, the independent variable (heavy metals) is categorical, while the dependent variable (water quality) continuous. It will therefore be suitable to analyze data using ANOVA. ANOVA is an analysis technique that compares individuals and group differences of subjects that are exposed to different sources treatments. Treatment in this study will be the different statuses of water sources containing heavy metals. (for example, water sources that are highly concentrated with heavy metals, water sources that are moderately concentrated with heavy metals and water sources that have low concentration of heavy metals.) ANOVA is usually used when data is made up of individual scores and the researcher wants to estimate the individual as well as the group differences as a result of treatment and determine if one variance is larger than another [18, 19]. Data will be collected in form of strong agreement, agree, no comment, disagree and strongly disagree. A response of strongly agree will be awarded 5, agree 4, no comment 3, disagree 2, strongly disagree 1 and the scores of each respondent on each variable added

together. Since each main variable has two other subsidiary variables, the maximum score for each variable on each objective will be 10 and the minimum will be 2 on each variable for each respondent. The responses of all respondents in each area, will be pooled together to get the overall score for each area. The scores for each area will then be converted into percentages. By expressing each score as a percentage fraction of the total. The scores of each area will be rated as follows:0 - 49 percent, low concentration of heavy metals in the water source, 50 -74 percent, moderate concentration of heavy metals in the water sources, and 75 -100 percent, there is high concentration of heavy metals in water sources. One-way ANOVA technique will be used to compare the differences between poor quality of water. This is in the view of the fact that the data will be made up of individual scores and because the researcher wants to estimate the individual as well as the group differences quality of water as a result of heavy metals in order to determine if one variable is bigger than the other. This is the domain of ANOVA .The data will be analyzed at .05 level of significance .This value ($\alpha=.05$) has been chosen at the discretion of the

researcher and because it is usually the most commonly used value .In this level of significance ,the researcher will be 95 % confident that any differences noticed are due to heavy metals and not a result of chance .Thus In 100 possible cases ,only 5 of such

differences could be due to chance If the significant result is found, then the strength of the significance will be determined through Omega square (ω^2) technique indicated in equation 1 below.

$$\omega^2 = \frac{SS_{BG} - (n - 1)MS_{WG}}{SS_T - MS_{WG}} \tag{1}$$

where:

- SS_{BG} = sum of squares between groups.
- MS_{WG} = mean square within groups
- SS_T = total sum of squares
- N = Number of groups.

Assumptions and limitations

An assumption is a supposition that a fact is true. The following factors; animal wastes, poor human disposal of human waste can also influence water quality, however through controlling animals from getting near water sources and proper disposal of human wastes, water pollution from the above mentioned organisms can be controlled. Water pollution by aquatic organisms may not be controlled because this organism particularly live in water and on top of that they are a source of food to living organisms. But they will not have significant effect on the results because their wastes are not too harmful to human and the environment. The major limitations of this study are inaccessibility of some places and

ignorance of the people to supply right information concerning sources and the effects of heavy metals in them. If all factors were constant, the researcher should have obtained the right information which would help predict the solution to such a problem. But several factors such as lack of sensitization of the public by the concerned people could not allow for this procedure. The use of common people and ignorant people could lower the validity and reliability of the study. But this is the most suitable technique in the circumstances because they are the common people that can provide information on the effect of heavy metals.

Ethical considerations

The major ethical problem in this study is privacy and confidentiality of the respondents. Obtaining valid sample will entail gaining access to specific lists and files which its self is an infringement on the privacy and confidentiality of the responds, but this is the only

way to construct a sampling frame and generate representative sample. The respondents will have the freedom to ignore items that they do not wish to respond to.

RESULTS

This study investigated the effect of heavy metals on water quality. This was in the light of the poor water quality being consumed by people leaving industries.

The data collected was analyzed using ANOVA technique.

Sources of heavy metals in water

The first objective of this study was to determine the sources of heavy metals in water sources. To achieve this objective, people who stay near areas with poor water were asked to mention the different water sources and the taste of water from different water sources. The people also were asked to mention common activities practiced in such areas. The sources of heavy metals were defined in terms of

natural sources and artificial sources. The major natural sources cited were; weathering, and artificial sources were; industrialization, mining, agricultural activities. Data on this objective was analyzed under the hypothesis that there is no relationship between effect of heavy metals and water quality in Makindye division in Kampala district. The results are summarized below in table 1.

Table .1: shows different sources of heavy metals in water sources with average mean and standard deviation from a given number.

S/N	Sources of heavy metals	Mean	Frequency	Standard deviation
1	Weathering	76.09	10	0.0812
2	Agricultural activities	62.06	35	0.1296
3	Mining	45.50	25	0.1878
4	industrialization	75.08	30	0.0712
	Total	258.73	100	0.0712

The results in the table above suggest that the means of metals in water sources is generally higher in both natural and artificial sources.

Toxic effects of heavy metals

The second objective of this study was to determine the toxic impacts of heavy metals on humans and other living organisms in Makindye division. To achieve this objective, people who live in areas suspected to have been polluted by heavy metals were given questionnaires to fill in the health issues they

have experienced and observation was taken on how some aquatic organisms were living in that area as compared to those living in unpolluted areas. Health conditions were categorized as water related diseases and air borne diseases and the results were as follows in table 2.

Table 2: shows results of the toxic effects of heavy metals on humans and other living organisms that were as a result of contaminated water and polluted air with their mean and standard deviation of a given number

S/N	Disease	mean	Frequency	Standard deviation
1	Water related diseases	70	65	0.092
2	Air related diseases	35	35	0.546

The results in table: 2 show that there is a significant problem of water pollution and this can be associated to heavy metals.

Remediation strategies to the effects of heavy metals

The third objective of this study was to determine the remediation strategies to the effects of heavy metals on water quality. To achieve this objective, the researchers had to identify the major sources of heavy metals so as to minimize such sources. The researcher also had to look for the possible alternative sources of

water. This is to avoid consumption of contaminated water with heavy metals. The data was analyzed using ANOVA to determine if heavy metals have a significant effect on water quality in Makindye division in Kampala district. The results of ANOVA are summarized below in table 3

Table 3: Summary of ANOVA based on sources of heavy metals

Sources of difference	Sum of squares	df	Mean square	F.	F _c	Sig
Between groups	1502	2	751			
Within groups	1612	98	164	45.675	3.070	0.08
Total	3114	100	915			

The results of table 3 indicate that there is a significant difference between sources of heavy metals and water quality. The study therefore establishes

that heavy metals affect water quality in Makindye division in Kampala district. The null hypothesis is therefore rejected. This means that heavy metals as

result of both artificial and natural sources affect water quality in Makindye division in Kampala district. The researcher also performed omega square test to determine the effect of heavy metals on water

quality. A value of 0.4693 was obtained. This suggests that heavy metals account for 46.93% of the poor water quality of people in Makindye division.

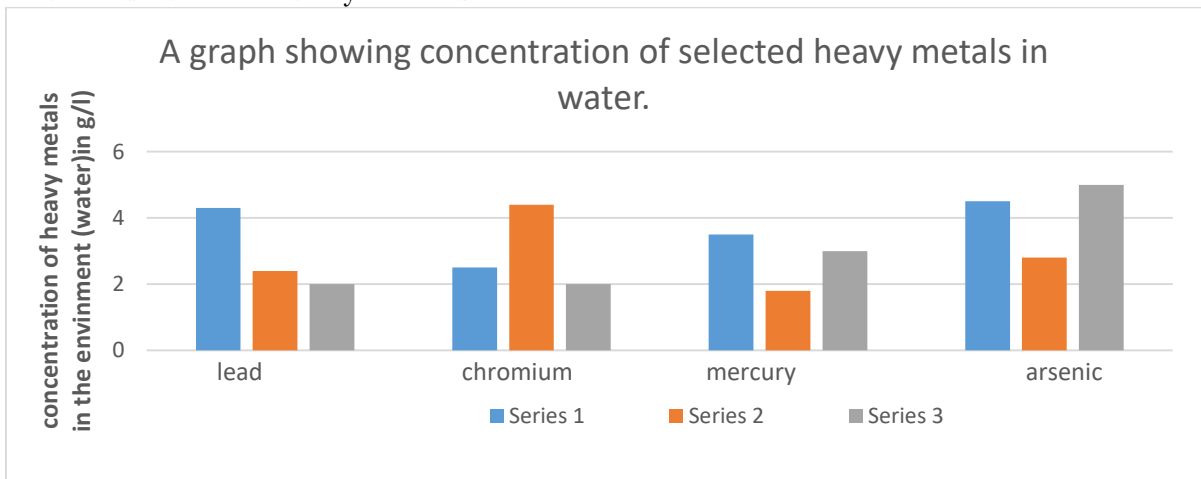


Figure 1: A graph showing concentration of selected heavy metals in water.

DISCUSSION

The first objective of this study was to determine the sources of heavy metals in water. Data analysis and interpretation revealed that the common sources of heavy metals in water are both natural and artificial. The major natural source of heavy metals is weathering and the artificial sources are industrialization, mining and agricultural activities. The findings indicate that weathering and industrialization are the key sources of heavy metals. Weathering is caused as a result of heat from the sunshine which makes the metals to expand and contract. This makes the metals become weak which are eventually washed away due to heavy rains. Industrialization has led to contamination of water through reaction of metals and the earth and also metals rub against each other when in use making them break into smaller particles which will eventually collect in the water sources. Also some of the industries use reagents that leach in to the soil and mix with water hence causing water pollution. Another source of heavy metals discovered was corrosion of metals that result from the metals dug underground for industrialization. This was not talked out by the early researchers but it is one of the significant source of metals. Therefore, industrialization would serve as the major source of heavy metals artificially. According to Angon et al [20] sources of heavy metal pollution may be natural or anthropogenic. Natural sources include; weathering of rocks, volcanic disasters. And human

causes according to [21] include discharge from domestic, industrial, and mining. The second objective of this study was to determine the toxic effects of heavy metals on living organisms. Data analysis and interpretation revealed two findings under this objective. It revealed that the effect of heavy metals to living organisms may lead to water related diseases and also air related diseases. Water related disease were on top compared to air related diseases. This is because more of the industrial wastes are dumped into water sources thus contaminating water. This contaminated water when consumed by living organisms can result in various diseases such as cancer, digestive problems among others.

The air related disease were on lower rate compared to water related diseases. The air related diseases were as a result of industrial fumes produced when heavy metals are heated. These effects could be either realized after a short time of exposure or even after number of years. This concluded that the time of realization of these effects was not certain but depends on the concentration of these metals in someone's body. According to Jaishankar et al., [22] Heavy metal toxicity has proven to be a major threat and there are several health risks associated with it. The toxic effects of these metals, even though they do not have any biological role, remain present in some or the other form harmful for the human body and its proper functioning. They sometimes act as a pseudo element of the body while at certain times they may

even interfere with metabolic processes. Few metals, such as aluminum, can be removed through elimination activities, while some metals get accumulated in the body and food chain, exhibiting a chronic nature. The third objective of this study was to determine the mitigating strategies of the effects of heavy metals. Data analysis and interpretation revealed that the mitigation strategies of the effects of heavy metals include; the use of other alternative sources of water leaving the water sources that have already been contaminated by heavy metal. The second alternative source is the discovery of the major sources of heavy metals such that those sources of heavy metals can be avoided for example

industrialization activities. But the major strategy of preventing the effect of heavy metals is finding the alternative sources of water leaving the ones that have already been contaminated by heavy metals. Other related studies concerning remedies to the effects of heavy metals were carried out by Upadhyay et al [23]. This study showed that the uptake of heavy metals using algae is an effective water pollution remediation measures. Algal remediation is considered an efficient, economical and eco-friendly method of removing pollutants from water. phytoremediation [24] is eco-friendly process that utilizes algae to remove industrial pollution or recover value added products from waste water.

CONCLUSION

This topic investigated the effect of selected heavy metals on water quality in selected springs in Makindye division. It was intended to determine the effect of heavy metals on water quality. This was in relation to the Water pollution due to heavy metal contamination in Makyindye division being a significant environmental concern that possess serious threat to living organisms. Heavy metals example lead, mercury, cadmium, arsenic, copper are highly toxic and have detrimental effects on both aquatic ecosystems and human health. These metals enter water sources through various pathways including industrial activities, mining operations, agricultural practices and urban runoff. Once in the water, heavy metals can accumulate in living organisms, leading to arrange of health issues and ecological imbalances. Efforts to mitigate heavy metal pollution in water include implementing strict regulations on industrial emissions and waste disposal practices, promoting sustainable agriculture to reduce pesticide and fertilizer run off, invest in waste water treatment technologies to remove heavy metals before discharge into water bodies and conducting regular monitoring of water quality to detect contamination early. It's upon this background that this study was to investigate the effect of heavy metals on water quality in Makindye division. The study specifically sought to answer the questions what are the sources of heavy metal contamination in water bodies? What are the long term effects of chronic exposure to low levels of heavy metals in

drinking water? How effective are different remediation techniques in reducing heavy metal levels in contaminated water? The study established that major sources of heavy metals in water sources were both natural and artificial. The natural sources included weathering whereas artificial sources include industrialization, mining and agricultural activities. For the case of toxic effects of heavy metals on living organisms, the study established that these heavy metals result into water related diseases and air related diseases. Water related diseases include cancer, digestive problems among others and this can be solved through alternative sources of water. The remediation strategies to the effects of heavy metals are given below;

Use of alternative sources of water, treatment of contaminated water sources so as to avoid health problems. In view of these findings ,the study concludes that the people who stay near industrialized areas should be provided with drugs for treatment of contaminated water before them using such water and if possible ,alternative sources of water for domestic use should be provided to them .This would serve as the best way of controlling the effects of heavy metals on water quality since it is very hard to stop weathering, industrialization .This must address the effects of heavy metals on water quality in living organisms .This means that the effect of heavy metals on water quality can be minimized if the public takes relevant measures as discussed above.

Recommendations

The researcher has argued in this report that discovering other alternative sources of water and treatment of the industrial wastes before they are released in to the water sources would be the best way of controlling the effects caused by heavy metals to living organisms. The study has also shown that weathering is one of the natural sources of heavy metals, industrialization, mining and agricultural activities are artificial sources of heavy metals on

water quality. The study argues that the best way of controlling the effect of heavy metals on water quality is through treatment of the wastes before disposal and the use of other alternative sources of water .It is against this background that the recommendations below are made .Despite its limitations, this study should be to determination of the key sources of heavy metals, environmental concerns. , immediate mitigation strategies of the effect of heavy metals

When the public becomes aware of the harmful effects of heavy metals, they will be in position to find all possible ways to mitigate the effects caused by heavy metals to living organisms. Basing on the generalizations on the findings of this study, the researcher recommends that the public should understand the sources of heavy metals so as to control heavy metal pollution of water, the public should also be able to know the toxic effects of heavy metals such that they derive techniques of preventing

such effects. In addition to the two recommendations above the public should also know the ways of preventing the effects of heavy metals on living organisms. This can be done through sensitizing the public on ways of preventing the effects of heavy metals by the concerned people, Provision of preventive equipment to the people so that they can use such equipment for preventing related effects to heavy metals.

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