DETERMINATION OF HEAVY METAL CONCENTRATIONS IN EFFLUENTS EMANATING FROM VEGETABLE OILS AND CHEMICAL INDUSTRIES IN NAIROBI COUNTY

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Abstract

The rate at which Kenya is urbanizing is alarming. Millions of Kenyans are relocating to urban centers every year to search for employment opportunities in industries. As a result of this rapid population growth and urbanization, there is a high demand for goods such as vegetable oils and detergents. These oils and detergents are contaminated with heavy metals through endogenous and exogenous sources. Most of these industries discharge their effluents in sewers, rivers and other water bodies without following the NEMA, KEBS and WHO guidelines. This project was therefore aimed at determining the concentration of Pb, Cd, Cr, Mn, Cu and Zn from effluents emanating from chemical and vegetable oil industries and determines their level of compliance. Samples from the two industries were collected on the same day at two sampling points; (i) Entry to the treatment plant for untreated effluents. (ii) Discharge from the treatment plant for treated effluents. Digestion of the samples was carried out using aqua-regia. Analysis of heavy metals was carried out using atomic absorption spectrophotometer. Physicochemical parameters were also determined using the standard method for the examination of waste and waste water.

The concentration of Cd, Zn, Mn and Cu were within the set standards of discharge with mean value ± standard deviation (sd) in the treated effluent of chemical industry as 0.02 ± 0.01, 0.44 ± 0.07, 0.64 ± 0.37 and 0.04 ± 0.01 respectively. Similar results were obtained from a vegetable oil industry where the mean concentration ± sd for Cd, Zn, Mn and Cu in the treated effluents were 0.02 ± 0.01, 0.39 ± 0.13, 0.56 ± 0.04 and 0.05 ± 0.01 respectively. Chromium was not detected in both untreated and treated effluents from the two industries. Lead concentration in chemical industry exceeded the KEBS limits. For the physicochemical parameters, Total dissolved substances (TDS) values in the chemical industry were within the limits however in the vegetable oil industry, the values exceeded the limits set by NEMA and KEBS. Electrical conductivity values in the treated effluents from the chemical industry were within the NEMA and KEBS limits while the conductivity values in treated effluents exceeded both limits. All the pH and temperature values were within the NEMA and KEBS limits.

Due to the presence of heavy metals and total dissolved substances in the effluents, regular monitoring of the effluent from these companies is important. NEMA should enforce the existing regulations for compliance.

Key Words: Heavy Metals, Effluents, Vegetable oils, Chemical Industries, Sampling
Introduction

Kenya is urbanizing at a faster rate, with rapid population growth. This has led to increase in industrial complexes to produce essential goods such as vegetable oils which are widely used for cooking food, processing cosmetics, pharmaceuticals and in chemical industries. The quality of vegetable oils can be evaluated by determination of several contaminants such as manganese (Mn), cadmium (Cd), lead (Pb), chromium (Cr), Zinc (Zn) and Copper (Cu).

A toxic heavy metal is any relatively dense metal or metalloid that is noted for its potential toxicity especially in environmental contexts. World Health Organization (WHO) has listed Pb, Cr and Cd as chemicals of major public concern. These toxic elements can be harmful even at very low concentrations when one is exposed to for a long period of time. Essential metals produce toxic effects when their intake is excessively elevated. The trace metals like Zn, Mn and Cu enhances the rate of oxidation of edible oils by increasing the generation of free radicals from fatty acids. The principle sources of oil contamination with heavy metals is their migration from arable soils into oil plants, during technological processes, processing vessels and packaging materials (Ching and Mirous, 2008). As a result of this industrial activities, if the toxic heavy metals from the raw materials are not treated they may results to problems of pollution and environmental degradation due to discharge of polluted waste water directly to the environment without going through the primary treatment (Lunnik and Zubenko, 2000). An effluent is defined by United States Environment Protection Agency (USEPA) as water-treated or untreated that flows out of a treatment plant, sewer or industrial outfall. This generally refers to wastes that are discharged into surface waters (Lunnik and Zubenko, 2000). The discharged untreated wastewater into the environment damages the quality of the receiving sinks. It is toxic to treatment processes, food chain, aquatic life and to human health. In order to mitigate against the negative effects of heavy metals, it is suitable that the effluent be treated prior to discharge to the environment. As a matter of concern, side effects resulting from the rapidly increasing industrial growth and heavy metal concentration in the environment, it has led to assessment of concentrations of the amount of heavy metals in effluents of vegetable oils and chemical industries in Nairobi Kenya

Main objective.

The main objective of this project was to determine the concentration of selected heavy metals such as Pb, Cd, Cr and trace elements such as Mn, Zn and Cu in effluent emanating from a chemical industry and vegetable oils manufacturing industry in Nairobi County.

Specific objectives

1. To determine the concentrations of Pb, Cd, Cr, Mn, Zn and Cu before and after treatment in effluents emanating from a chemical and vegetable oil industry.
2. To determine the level of compliance of the heavy metal contaminants in the treated effluents
3. To carry out analysis on physicochemical parameters that include pH, temperature, electrical conductivity and total dissolved solids of the industrial effluents before and after treatment.
Justification of the study

The research work targets the general population working, living and consuming products from the chemical and oil industries. The effluents from these industries if not monitored may contain toxic heavy metals and other contaminants which are a threat to living organisms and induces severe effects to human health. It is therefore expected that data from this study will assist industries to come up with correct mitigation measures to ensure that the concentration of heavy metals and other contaminants in the effluents meets the set standards by National Environment Management Authority and the Kenya Bureau of standards.

Materials and method

Study area
The samples that were analyzed in the laboratory were collected from a chemical industry located at industrial area along Enterprise road as shown in figure 1 and from a vegetable oil industry along Mombasa road as given in Figure 2.

Figure 1: Map showing sampling points from in a chemical industry.

Figure 2: A map showing sampling point in a vegetable oil refining industry.
Project design

Sample collection

Clean bottles with fitting stoppers of a capacity of 500ml were used. A sample of 250 ml was collected in triplicate from two discharge points. The sample bottles were washed thoroughly with detergents and nitric acid. They were rinsed with distilled water to remove acids. Before sampling the bottles were washed with the waste water several times. The samples were then collected and labelled correctly and then stored in a refrigerator.

Sampling

The sampling process was carried out on 29th August 2017 during the day at 1pm from the vegetable oil industry and at 3pm from the chemical industry at two chosen points from both industries. The wastewater samples were collected in triplicates at two sampling points. That is influent channel before treatment and the effluent channel after primary and subsequent treatment before discharge into the public sewer. The samples were labelled correctly and transported conveniently into the laboratory and stored under refrigeration waiting for analysis.

Figure 3: (a) Effluent channel where before treatment sampling was done.
(b) Waste water treatment plant where after treatment sampling was done.
Principal of sample digestion
The principle of sample digestion is to break down the bonds between heavy metals and matrixes. The type of acid to be used depends on sample to be digested. Organic sample materials like vegetable oils are generally decomposed into CO\textsubscript{2} with the aid of oxidizing acids such as nitric acid and reagents such as hydrogen peroxide and completely mineralized. Detergents are frequently dehydrated in situ by the addition of sulphuric acid. Samples are safely decomposed by slow heating. Inorganic samples are completely mineralized and dissolved. In this case concentrated hydrochloric acid and concentrated nitric acid were used. The solubility of the resulting salts must be considered so that the solution remains stable for longer periods of time.

![Figure 4 (a) digestion of the sample](image)

![Figure 4 (b) digested sample filtration](image)

Procedure for sample digestion
- The aqu-regia was prepared by mixing 75ml of concentrated nitric with 25ml of concentrated 1M hydrochloric acid.
- 30ml of the sample was measured and transferred to the flat bottomed flask, 10ml mixture of aqua reagent solution prepared was added and resultant solution mixed thoroughly.
- 1ml of concentrated per-chloric acid was then added to the solution heated for about 30 minutes on a hot plate as shown in Figure 4 (a) until the volume reduced to about 10ml, distilled water was added and heating continued for about 20 minutes.
- The solution was left to cool and then filtered.
- The filtrate was then diluted with distilled water to 50ml.
- The blank solution was prepared using distilled water and the water sample.
- The digested samples were stored in sample bottles that had been rinsed with nitric acid and distilled water.
- The samples were ready for analysis using atomic absorption spectrophotometer (AAS).
Laboratory analysis

The analysis of the samples to determine the concentration of Cd, Pb, Cr, Mn, Cu and Zn ions was carried out in the Department of Chemistry Analytical Chemistry Laboratory in the University of Nairobi. Samples were analyzed according to standard method for determination of water quality.

Table 1: Detection limit of Metals and flames used

<table>
<thead>
<tr>
<th>Metal</th>
<th>Flame</th>
<th>Detection limit mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>Air/acetylene flame</td>
<td>0.01</td>
</tr>
<tr>
<td>Manganese</td>
<td>Air/acetylene flame</td>
<td>0.1</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Air/acetylene flame</td>
<td>0.02</td>
</tr>
<tr>
<td>Chromium</td>
<td>Air/acetylene flame</td>
<td>0.01</td>
</tr>
<tr>
<td>Zinc</td>
<td>Air/acetylene flame</td>
<td>0.02</td>
</tr>
<tr>
<td>Copper</td>
<td>Air/acetylene flame</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Principle of atomic absorption spectrophotometer

Atomic absorption spectroscopy was a method of choice for analysis of Cd, Mn, Pb, Cu, Zn and Cr. This technique is based on atomization where a suitable flame converts the metal ions of interest (Cd, Mn, Pb, Cu, Zn and Cr) into atoms. The technique basically used the principle that free atoms (gas) generated in an atomizer can absorb radiation at specific frequency. AAS shown in Figure 5 quantified the absorption of ground state atoms in the gaseous state. The atoms absorbed ultraviolet or visible light and made transitions to higher electronic energy levels. The analyte concentrations were determined from the amount of absorption. Hollow cathode lamps that were used in AAS contained a hollow cylindrical cathode made of Cd, Mn, Pb, Cu, Zn and Cr that were determined. Acetylene flame was used. Each element had its own unique lamp which was used for analysis.

Figure 5: A photo showing the AAS used in this study

Physicochemical parameters

The physicochemical parameters determined included pH, electrical conductivity, total dissolved solids and temperature.

pH

The pH of the sample solution was measured in the laboratory using a pH meter (Hanna instrument pH tester). The pH meter was switched on and socket dipped into the solution. The pH value was recorded (APHA, 1998)

Electrical conductivity

Electrical conductivity of the sample solution was measured in the laboratory using electrical conductivity meter and socket model. Conductivity meter was switched on and the probe dipped into the sample solution in the beaker. The readings were recorded in µScm-1
Total dissolved solids (TDS)
TDS measured in the laboratory using conductivity meter. The result was recorded in mg/l.

Temperature
The temperature of the sample solution was determined in the laboratory using a thermometer and the results recorded in degrees Celsius.

Results and discussion
This section presents results obtained from the analysis of heavy metals and physicochemical parameters in effluents from vegetable oil industry and the chemical industry in Nairobi county. The average concentration levels ± standard deviation and the range of the elements analyzed (Pb, Cd, Cr, Mn, Cu and Zn) are compared with maximum permissible limits (MPL) given in the Table 2. Heavy metals were analyzed using Atomic absorption spectrophotometer.

Table 2: Concentration mean ± sd for heavy metals and parameters measured at two discharge points

<table>
<thead>
<tr>
<th>Parameter/ metal</th>
<th>Vegetable oil (mg/l)</th>
<th>Chemical industry (mg/l)</th>
<th>Vegetable oil (mg/l)</th>
<th>Chemical industry (mg/l)</th>
<th>NEMA (MPL)</th>
<th>KEBS (MPL)</th>
<th>WHO (MPL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± sd</td>
<td>Mean ± sd</td>
<td>Mean ± sd</td>
<td>Mean ± sd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pb (mg/l)</td>
<td>0.11±0.05</td>
<td>0.37±0.09</td>
<td>0.06±0.02</td>
<td>0.09±0.03</td>
<td>0.15</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Mn (mg/l)</td>
<td>0.52±0.08</td>
<td>0.77±0.45</td>
<td>0.56±0.04</td>
<td>0.64±0.37</td>
<td>1.0</td>
<td>-</td>
<td>0.5</td>
</tr>
<tr>
<td>Cr (mg/l)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>2.0</td>
<td>2.0</td>
<td>0.05</td>
</tr>
<tr>
<td>Cd (mg/l)</td>
<td>0.14±0.11</td>
<td>0.03±0.01</td>
<td>0.02±0.01</td>
<td>0.02±0.01</td>
<td>0.5</td>
<td>0.05</td>
<td>0.005</td>
</tr>
<tr>
<td>Cu (mg/l)</td>
<td>0.17±0.03</td>
<td>0.06±0.01</td>
<td>0.05±0.01</td>
<td>0.04±0.01</td>
<td>1.5</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Zn (mg/l)</td>
<td>0.51±0.24</td>
<td>2.19±0.07</td>
<td>0.39±0.13</td>
<td>0.44±0.07</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Electrical conductivity (µs/cm)</td>
<td>3400</td>
<td>574</td>
<td>5490</td>
<td>115</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total dissolved solids (mg/l)</td>
<td>1071</td>
<td>288</td>
<td>2780</td>
<td>47.7</td>
<td>1200</td>
<td>2000</td>
<td>1500</td>
</tr>
<tr>
<td>pH</td>
<td>6.92±0.02</td>
<td>7.21±0.02</td>
<td>7.42±0.02</td>
<td>7.53±0.01</td>
<td>6.0-9.0</td>
<td>6.0-9.0</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>22.6</td>
<td>22.8</td>
<td>22.5</td>
<td>22.8</td>
<td>20-35</td>
<td>35</td>
<td>35</td>
</tr>
</tbody>
</table>
KEY
BTE- Before treatment effluent
ATE – After treatment effluent
MPL- maximum permissible limits
Mg/l -milligrams per litre = parts per million
µS/cm-micro Siemens/centimeter
ND- Not detected. Lowest detection limit was 0.01mg/l
SD-Standard deviation p=0.05

The average concentration ± standard deviation (sd) results of Pb, Mn, Cr, Cd, Zn and Cu analyzed by AAS and physicochemical parameters determined in the laboratory were compared with the maximum permissible limits of NEMA, KEBS and WHO.

Trace and Heavy metals
Lead
From Table 2, the mean concentration of lead in the treated effluent was found to be 0.06±0.02 mg/l and 0.09±0.03 mg/l in vegetable oil and chemical industry respectively while the mean concentration in untreated effluent was 0.11±0.05mg/l and 0.37±0.09mg/l in vegetable oil and chemical industry respectively. The concentration of lead in treated effluents from both industries exceeded the KEBS limit of 0.05mg/l. The source of lead may have resulted from the pipe that carries the wastewater to the treatment plant. According to (Fartel, 1991), the treatment method used may have contained lead ions. Lead that occurs in dust and soil particles normally contaminates cleaned surfaces. Lead in painted waste water tanks may also be a source of contamination. High levels of lead in adult population have reproductive effects such as decreased sperm count and spontaneous abortions in women. Research in previous papers shows that acute exposure to lead causes damages to the brain, kidney and brings about gastrointestinal diseases. Chronic exposure results in adverse effects in the blood, central nervous system and blood pressure (ATDSR, 2012). Moreover, there is no known biological function of lead.

Manganese
The mean concentration of manganese for the sample analyzed in untreated waste water was 0.52 ± 0.08 and 0.77 ± 0.45 for vegetable oil and chemical industry respectively while the mean concentration for treated waste water was 0.56 ± 0.04 and 0.64 ± 0.37 for vegetable oil and chemical industry respectively Table 2.

Treated wastewater had higher concentrations of Manganese ions than untreated wastewater. This may have been resulted from the treatment process of wastewater. The concentration of treated wastewater ready for discharge was below the maximum permissible limits of 1.0mg/l set by NEMA. Manganese was highly concentrated in peanut which is a raw material in vegetable oil industries. Mn$^{2+}$ in the body is responsible for proper growth of human bone structure and it increases the mineral density of spinal bone.

Manganese prevents diseases by monitoring the activity of free radicals in human body which have the potential to damage cells that causes cancer and it controls sugar level by normalizing insulin synthesis and secretion (Marques, 2012).
**Chromium**
Chromium has various oxidation states ranging from Cr (II) to Cr (IV). Cr(VI) is the most toxic. In all the samples that were analyzed chromium was not detected. The lowest detection limit of the Atomic absorption spectrophotometer that was used in the laboratory analysis was 0.01mg/l. According to NEMA and KEBS, the maximum permissible limit of chromium is 2.0mg/l. The absence of chromium in the samples may be due to the industries using chromium free raw materials and an environment that is not contaminated with chromium ions. Adequate chromium nutrition reduces the risk factors associated with cardiovascular diseases as well as diabetes mellitus (Reilly, 2002). Chromium stored in hair and blood in the body is responsible for stimulating insulin and controlling blood cholesterol level. Low level exposure can cause skin irritation and nerve tissue problems. Long term exposure can cause kidney and liver damage.

**Cadmium**
As can be observed from Table 2 the mean concentration of cadmium in raw wastes was 0.14±0.01mg/l and 0.03±0.01mg/l in vegetable oil and chemical industry respectively. In treated wastes the mean concentration was 0.02±0.01mg/l and 0.02±0.01mg/l in vegetable oil and chemical industry respectively. In all samples the mean concentration of treated effluent was below the maximum permissible limits of 0.5mg/l for NEMA and 0.05mg/l for KEBS. The high concentration of Cd in untreated effluents from vegetable may be due to its natural occurrence in soil and environment. Cadmium is normally present in trace amounts in certain foods such as leafy vegetables, potatoes, grains, seeds, liver and kidney (Saturug, 2003). As a result the raw materials in vegetable oil extraction may be contaminated. Foodstuffs that are rich in Cd can greatly increase its concentration in the human body. Cadmium is a highly toxic metal and is usually transported to the liver through blood where it bonds to form complexes that are transported to the kidney. Exposure to cadmium is commonly determined by measuring its levels in blood or urine.

**Copper**
The presence of copper and iron catalyzes the decomposition of hydro peroxides which may lead to formation of unwanted substances in vegetable oils. From the laboratory analysis of samples, the mean concentration of copper in the treated effluents was 0.05±0.01mg/l and 0.04±0.01mg/l for vegetable oil and chemical industry (Table 2). The concentration of the discharged effluents was below the maximum permissible limits of 1.0mg/l. The low concentration of copper in the treated effluents may be due to proper treatment process. The trace amount that was detected in the samples may have resulted from copper that is frequently detected in the atmosphere even if the site is far away from anthropogenic sources. Trace amounts of copper in the body speeds up the rate of oxidation of edible oils by increasing the generation of free radicals from hydro-peroxides. The deficiency of copper in the body may lead to diseases such as hypo anemia, leucopenia and osteoporosis in children (Reilly, 2002)
**Zinc**

Zinc Dialyldithiophosphate (ZDDP) is normally added in vegetable oils to produce more stable lubricants that is used in lubricating machines. From Table 2, the mean concentration of zinc in untreated effluents was 0.81±0.24mg/l and 2.19±0.07mg/l for vegetable oil and chemical industry respectively while in treated effluents, the mean concentration was 0.39±0.13mg/l and 0.44±0.07mg/l for vegetable oil and chemical industry respectively. The results from all the samples were below the maximum permissible limits of 5.0mg/l from both NEMA and KEBS. The concentration of untreated effluents was much higher than the treated one likely because of the presence of zinc in raw material such as corn seed. Low concentration in treated effluent was because of proper treatment process of waste water. Zinc in the body helps in proper growth, blood clotting, thyroid function, protein and DNA synthesis. High concentration of Zn in the body produces toxic effects on the immune system and copper levels (Fosmire, 1990).

**Physicochemical parameters**

**Electrical conductivity**

From Table 2, the mean electrical conductivity of untreated waste from the vegetable oil and chemical industry was 3400µS/cm and 574µS/cm, respectively and for treated waste the electrical conductivity was 5490µS/cm and 115µS/cm for vegetable oil industry and chemical industries respectively. The conductivity of raw wastes from both vegetable oil industry and chemical industry was higher than the allowed limit of 400µS/cm in drinking water. After treatment the conductivity increased in effluents from vegetable oil industry. The high conductivity may be due to presence of dissolved salts, inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds. As a result this shows that the water is saline. The high conductivity of treated waste from vegetable oil may have resulted from the metal ions that were used during treatment process.

**Total dissolved solids (TDS)**

The mean concentrations of untreated effluents from Table 2 was 1071mg/l and 288mg/l for vegetable oil and chemical industry respectively while TDS in treated waste water had mean concentrations of 2780mg/l and 47.7mg/l for vegetable oil and chemical industries respectively. TDS were more concentrated in effluents from vegetable oils likely because of by products from degumming processes which are discharged as wastes and the nature of the piping used to convey waste water. TDS values in treated waste water in vegetable oil industry were higher than the set standards by NEMA of 1200mg/l and KEBS of 2000mg/l. This may be due to presence of chemicals and ions used in the water treatment process. As a result, high concentration of dissolved ions may cause the water to be corrosive, salty or brackish taste. This may result in formation of scale and interfere with water heaters.
pH
The pH of untreated effluent was 6.92±0.02 and 7.21±0.02 from vegetable oil industry and chemical industry respectively (Table 2). The pH of treated effluent was 7.42±0.02 and 7.53±0.01 for vegetable oil industry and chemical industry respectively. The pH values were within the set standards by both NEMA and KEBSA of 6.0-9.0. The high pH of treated effluents indicates the solution is alkaline. This may have been caused by the application of alkaline solution during refining process and use of chemicals during the waste water treatment. The pH of a solution can have several effects on the structure and activity of enzymes. The pH of water is important for living organisms as they can survive in a narrow range of pH from slightly acidic to slightly alkaline (Goher, 2002).

Temperature
From Table 2, the temperature of the untreated wastewater was 22.6°c and 22.8°c for vegetable oil industry and chemical industry respectively while the temperature of treated effluent was 22.5°c and 22.8°c for vegetable oil and chemical industry. All the treated effluent temperatures from the two industries were within the set limits of 20-35°c. Water temperatures regulate the metabolism of aquatic ecosystem. High temperatures reduce the ability of water to hold essential gases like oxygen.

Figure 6: Bar graph showing concentration of metals in untreated and treated effluents from a chemical industry
Comparison of Pb, Mn, Cr, Cd, Cu and Zn in untreated and treated effluent from a chemical industry was evaluated as shown in Figure 6. The levels of Pb, Mn, Cd, Cu and Zn were higher in untreated effluents but reduced after treatment. This shows the treatment method was efficient and appropriate. Chromium was not detected in both effluents.

Figure 7: Bar graph showing concentration of metals in untreated and treated effluents from a vegetable oil industry

Comparison of metals in untreated and treated effluents from a vegetable oil industry. From Figure 7, the concentration of lead in untreated effluent was higher than that of treated effluent. Similar observations were made for cadmium, zinc and copper implying the treatment method used was effective. However, levels of manganese were higher in treated effluent than in untreated effluent. This was likely caused by presence of manganese ions in the chemicals used during treatment and existence of manganese in atmospheric air and rocks. Chromium was not detected in both effluents.

Table 3: F-test showing comparison of metal concentrations in vegetable oil industry. P=0.05 n=3

<table>
<thead>
<tr>
<th>Metal</th>
<th>$F_{calculated}$</th>
<th>$F_{critical}$</th>
<th>Difference</th>
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</thead>
<tbody>
<tr>
<td>Mn</td>
<td>4.00</td>
<td>19.00</td>
<td>Not significant</td>
</tr>
<tr>
<td>Zn</td>
<td>11.76</td>
<td>19.00</td>
<td>Not significant</td>
</tr>
<tr>
<td>Pb</td>
<td>6.25</td>
<td>19.00</td>
<td>Not significant</td>
</tr>
<tr>
<td>Cd</td>
<td>121</td>
<td>19.00</td>
<td>Significant</td>
</tr>
<tr>
<td>Cu</td>
<td>9.00</td>
<td>19.00</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

Applying the F-test in Table 3, the results shows that the concentration of all metals in untreated effluents analyzed except cadmium that were not significantly different from those of treated effluents.
Table 4: F-test showing comparison of metal concentrations in a chemical industry. P=0.05 n=3

<table>
<thead>
<tr>
<th>Metal</th>
<th>F_calculated</th>
<th>F_critical</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn</td>
<td>1.48</td>
<td>19.00</td>
<td>Not significant</td>
</tr>
<tr>
<td>Zn</td>
<td>1.00</td>
<td>19.00</td>
<td>Not significant</td>
</tr>
<tr>
<td>Pb</td>
<td>9.00</td>
<td>19.00</td>
<td>Not significant</td>
</tr>
<tr>
<td>Cd</td>
<td>1.00</td>
<td>19.00</td>
<td>Not significant</td>
</tr>
<tr>
<td>Cu</td>
<td>1.00</td>
<td>19.00</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

From Table 4, the F-test results shows that the concentration of all metals in untreated effluents analyzed were not significantly different from those of treated effluents.

**Conclusion and Recommendations**

**Conclusion**

The main purpose of this project was to determine the concentration of Pb, Mn, Cd, Cr, Zn and Cu in industrial effluents of a vegetable oil industry and a chemical industry and find out if the treated effluent that is ready for discharge meets the set standards by NEMA and KEBS. From the hypothesis, the study yielded some useful results. The discharged effluent contained some concentration of trace and heavy metals such as lead and dissolved solids that exceeded the permissible limits. The high concentration of lead in the treated wastewater especially from the chemical industry may have negative impact on the receiving water bodies. Continued discharge and accumulation of heavy metals in the environment can result in harmful side effects to the general population especially those living in the vicinities of a chemical and vegetable oil industries.

**Recommendations**

From the study, the following recommendations are suggested in order to avoid the discharge of pollutants and toxic heavy metals emanating from a chemical and vegetable oil industry into public sewers.

I. With the concentration of lead exceeding the maximum permissible limits in the treated effluents from the chemical industry, other technological method that is cost effective should be employed to reduce the concentration of lead and other metals in effluents that is discharged into public sewers.

II. NEMA and KEBS should set up policies and strictly enforce existing regulations to avoid non compliance.

III. Periodic monitoring of the effluent by these companies is necessary.
References


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