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Determination of Some Heavy Metals in an Industrial Effluents from Bompai Industrial Area, Kano

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Abstract The pH, conductivity, and concentrations of Cadmium, Chromium, Copper, Iron, and Lead in Bompai industrial effluents were determined. The pH and conductivity values obtained are (6.77 ± 0.07 s/m) and (51.78 ± 13.51 s/m) respectively. The mean concentrations of the metals determined by Atomic Absorption Spectrophotometer are Cadmium (2.8535 ± 0.7716 mg/l), Chromium (4.1667 ± 2.1115 mg/l), Copper (1.8382 ± 0.8799 mg/l), Iron (2.9444 ± 0.7568 mg/l) and Lead (1.2749 ± 0.7716 mg/l). These values are compared with (FEPA, 1991) and (WHO, 1974) permissible limits which indicated that most of the values are above the aforementioned limits.

Keywords effluent, concentration, permissible limit, conductivity, pH, mean, standard deviation

1. Introduction

1.1. Industrial Effluents

Industrial effluents contain great variety of undesirable toxic substances such as heavy metals, in different concentrations which could causes serious diseases to both human and animals [1].

The presence of toxic substances of organic and inorganic matter in marine, atmosphere and soil result in environmental pollution. These substances can also be transferred either directly and indirectly into human and animals bodies where they affect tissues like liver, lungs, etc [2].

1.2. Heavy Metals

Heavy metals are those elements that have relatively high density and are poisonous even at low concentrations [3]. These elements range from Copper to Mercury in the periodic table with atomic weight between 63.54 and 200.59 respectively and specific gravity greater than 4.0 [4].

1.2.1. Cadmium (Cd)

1.2.1.1. Properties

- Atomic number: 48
- Atomic weight: 112.41 g/mol
- Boiling point: 1041 K
- Crystal structure: Hexagonal

- Electrical conductivity: 14.2 x 10^6 S/m
- Melting point: 594 K

1.2.1.2 Environmental effects

Cadmium poisoning caused by inhalation of cadmium containing fumes results initially in metal fume fever it progresses to chemical pneumonitis, pulmonary edema and death [5]. Long term exposure of Cadmium is associated with renal disfunction. High exposure can lead to lung cancer. It may also cause bone defect [6].

1.2.2 Chromium (Cr)

1.2.2.1 Properties

- Atomic number: 24
- Atomic weight: 51.996 g/mol
- Boiling point: 2945 K
- Crystal structure: Body centred cubic
- Electrical conductivity: 9.7 x 10^6 S/m
- Melting point: 2130 K

1.2.2.2 Environmental effects

Chromium occurs in +2, +3, +5, and +6 oxidation states. The +6 state is highly toxic. Exposure to high doses for long period results in lung cancer, liver and kidney damage [7].

1.2.3 Copper (Cu)

1.2.3.1 Properties

- Atomic number: 29
- Atomic weight: 63.546 g/mol
- Boiling point: 2830 K
- Crystal structure: Faced centred cubic
- Electrical conductivity: 6.0 x 10^6 S/m
- Melting point: 1351 K

1.2.3.2 Environmental effects

Copper is essential for healthy growth of many plants and animals. The diet of human beings includes 2.0 mg of Copper per day. Copper can be toxic in large quantities to lower organisms such as fungi and algae. It has less effect on human because it is incompletely absorbed while the rest excreted readily. Intake of 175-250 ppm of Copper may cause damage to liver, brain nervous system, reproductive system and structure of the hair [8-10]. It causes vomiting and sometimes diarrhea in man [8].

1.2.4 Iron (Fe)

1.2.4.1 Properties

- Atomic number: 26
- Atomic weight: 55.84 g/mol
- Boiling point: 3135 K
- Crystal structure: Face centred cubic
- Electrical conductivity: 11.2 x 10^6 S/m
- Melting point: 1809 K

1.2.4.2 Environmental effects

Iron is needed in haemoglobin and several enzymes. The intestine regulates the dietary iron absorbed. The high serum iron level renders individual mores susceptible to infection [6]. Inbhalation of iron fumes causes pneumonia and sideosis, this includes the toxic effect of some carcinogenic gases like sulphur dioxide, respiratory diseases such as bronchitis may set in [10-11].

1.2.5 Lead (Pb)

1.2.5.1 Properties

- Atomic number: 82
- Atomic weight: 207.2 g/mol
- Boiling point: 2021 K
- Crystal structure: Face centred cubic
- Electrical conductivity: 4.8 x 10^6 S/m
- Melting point: 600 K

1.2.5.2 Environmental effects

Lead is liberated into the environment mainly from exhaust pipes of automobiles smelters and mining industries [12]. Alkyl lead compounds in the environment are expected to have more profound physiological effects than the inorganic lead and hence more toxic. Massive exposure to lead can result in lead poisoning or plumbism. Lead poisoning is caused by the absorption of lead from the intestinal tract, through the lungs or skins. Lead causes brain damage in children and adults and deformity in children. Lead poisoning can also cause low intelligent quotient in children and high blood pressure in adults. If the threshold level of 0.5 mg is exceeded, it causes anaemia, paralysis and even death. Chronic lead exposure has been associated with heart diseases, gastric and duodenal ulcers [12].

2. Experimental

2.1 Materials and Methods

- Beaker (400 cm^3)
- Conical flask (250 cm^3)
- Measuring cylinder (10, 100 cm^3)
- Glass rod
- Pipette (5, 10, 25 cm^3)
- Volumetric flask (50, 100, 250, 500, 1000 cm^3)
- Whatman No. 42 filter paper
- Buck scientific 210 VGP atomic absorption spectrophotometer
- Labtech Digital pH meter
- 4010 Jenway conductivity meter

2.2 Reagents

- Concentrated sulphuric acid (95-97 % W/V, 98.08 g/mol, p = 1.89 g/cm^3)
- Concentrated nitric acid (70 % W/V, 63.01 g/mol, p = 1.42 g/cm^3)
- Concentrated orthophosphuric acid (85 % W/V, 98.00 g/mol, p = 1.7 g/cm^3)
- Potassium dichromate
- Copper (II) nitrate
- Zinc nitrate
- Ferrous sulphate
- Lead (II) acetate

2.3 Sampling

2.3.1 Sample collection

Effluent samples from Bompai industrial areas, Kano were collected in plastic containers and labelled as follows;
S: sample collected from Golden sesame snap company
M: sample collected at the meeting point of all effluents in the industrial area
R: sample collected at point of entry of effluents to Jakara River.
Subscripts 1,2,3 are written to show that the samples were collected in the first, second, and third weeks respectively.

2.4 Digestion of Samples

To 100 cm^3 of a sample in a 400 cm^3 beaker was added to 5 cm^3 of concentrated nitric acid. The mixture was evaporated on a hotplate in a fume cupboard until its volume reduced to 20 cm^3. Another 5 cm^3 of the acid was added and the solution boiled. It was cooled, filtered and made to mark with deionised water in a 100 cm^3 volumetric flask [13].

2.5 Determination of Sample pH

The pH values of the samples were determined using Labtech digital pH meter. The meter was switched on and allowed to warm up for about 15 minutes. It was then standardised with three reference buffer solutions of pH 4.0, 6.8, and 9.18.
The electrode of the meter was thoroughly rinsed with distilled water between measurements. Results are given in table 3.1.1.

2.6 Determination of Conductivity

The conductivity of the sample was determined using 4010 Jenway conductivity meter. The meter was switched on and allowed to warm up for about 15 minutes. The electrode was thoroughly rinsed with distilled water and then introduced directly into the sample to measure the conductivity. Results are given in table 3.1.1.

2.7 Sample Analysis

Concentrations of Cadmium, Chromium, Copper, Iron and Lead in the effluent samples were analysed using BUCK Scientific 210 VGP atomic absorption spectrophotometer.
The results of each sample was the mean of four replicate reading.

3. Results and Discussion

3.1 Results

3.1.1 Tables

Table 3.1.1 pH and conductivity values of Bompai industrial effluents

S/N	Code	Conductivity (S/M)	pH
1	S1	33	6.86
2	S2	59	6.72
3	S3	54	6.76
4	M1	32	6.81
5	M2	55	6.63
6	M3	68	6.78
7	R1	45	6.87
8	R2	63	6.73
9	R3	48	6.74
Mean:		51.78	6.77
Stdev.:		13.51	0.07

Table 3.1.2: Concentrations of Cd in Bompai industrial effluents

		Concentration (mg/dm^3)					
S/N	**Code**	**A**	**B**	**C**	**D**	**Average**	**Stdev.**
1	S1	2.7272	2.7272	2.7272	3.6363	2.9545	0.4545
2	S2	3.6363	1.8181	2.7272	2.7272	2.7272	0.7422
3	S3	3.6363	3.6363	4.5454	3.6363	3.8636	0.4545
4	M1	1.8181	1.8181	1.8181	1.8181	1.8181	0.0000
5	M2	2.7272	2.7272	3.6363	2.7272	2.9545	0.4545
6	M3	3.6364	4.5455	3.6364	3.6364	3.8636	0.4545
7	R1	0.9091	1.8182	2.7273	2.7273	2.0455	0.8704
8	R2	3.6364	3.6364	3.6364	2.7273	3.4091	0.4545
9	R3	1.8182	1.8282	2.7273	1.8182	2.0455	0.4545

Table 3.1.3: Concentrations of Cr in Bompai industrial effluents

		Concentration (mg/dm^3**)**					
S/N	**Code**	**A**	**B**	**C**	**D**	**Average**	**Stdev.**
1	S1	0.6667	1.3333	1.3333	1.3333	1.1667	0.2886
2	S2	2.6667	3.3333	3.3333	3.3333	3.1667	0.2886
3	S3	5.3333	4.6667	4.6667	4.0000	4.6667	0.4714
4	M1	1.3333	2.0000	2.0000	2.0000	1.8333	0.2886
5	M2	4.0000	4.0000	4.0000	4.6667	4.1667	0.2886
6	M3	7.3333	7.3333	7.3333	6.6667	7.1667	0.2886
7	R1	3.3333	3.3333	3.3333	3.3333	3.3333	0.0000
8	R2	5.3333	4.6667	4.6667	4.0000	4.6667	0.4714
9	R3	6.6667	6.6667	6.6667	9.3333	7.3333	1.1547

Table 3.1.4: Concentrations of Cu in Bompai industrial effluents

		CONCENTRATION (mg/dm^3)					
S/N	**Code**	**A**	**B**	**C**	**D**	**Average**	**Stdev.**
1	S1	1.6666	1.7647	1.8627	1.6666	1.7401	0.0938
2	S2	2.7451	2.5490	2.4509	2.7450	2.6225	0.1470
3	S3	1.0784	0.9803	0.9803	1.0784	1.0294	0.0566
4	M1	0.9803	1.0784	2.1568	10784	1.3235	0.5574
5	M2	3.6274	3.8235	3.6274	3.6274	3.6764	0.0980
6	M3	1.5686	1.4705	1.7647	1.7647	1.6421	0.1470
7	R1	0.6862	0.7843	0.7843	0.7843	0.7598	0.0490
8	R2	1.6666	1.7647	1.7647	1.5686	1.6911	0.0938
9	R3	1.9607	2.0588	2.0588	2.1568	2.0588	0.0800

Table 3.1.5: Concentrations of Fe in Bompai industrial effluents

		Concentration (mg/dm^3)					
S/N	**Code**	**A**	**B**	**C**	**D**	**Average**	**Stdev.**
1	S1	3.2000	3.2000	2.4000	3.2000	3.0000	0.4000
2	S2	4.0000	4.0000	4.0000	4.4000	4.1000	0.2000
3	S3	2.8000	2.0000	2.8000	2.8000	2.6000	0.4000
4	M1	2.4000	2.8000	2.8000	2.8000	2.7000	0.2000
5	M2	1.6000	1.6000	1.2000	3.6000	2.0000	1.0832
6	M3	3.6000	3.2000	2.8000	3.2000	3.2000	0.3265
7	R1	2.0000	2.0000	2.0000	2.4000	2.1000	0.2000
8	R2	4.0000	4.0000	4.0000	4.4000	4.1000	0.2000
9	R3	2.8000	2.8000	2.4000	2.8000	2.7000	0.2000

Table 3.1.6: Concentrations of Pb in Bompai industrial effluents

		Concentration (mg/dm^3)					
S/N	**Code**	**A**	**B**	**C**	**D**	**Average**	**Stdev.**
1	S1	0.4411	0.4411	0.2941	0.4411	0.4044	0.0735
2	S2	1.3235	0.8823	0.7352	1.0294	0.9926	0.2511
3	S3	0.8823	0.5882	0.7352	0.7352	0.7352	0.1200
4	M1	0.5882	0.5882	0.8823	0.7352	0.6985	0.1407
5	M2	1.0294	1.1764	1.0294	1.0294	1.0661	0.0735
6	M3	2.5000	2.2058	2.0588	2.0588	2.2058	0.2079
7	R1	0.8823	0.7352	0.7352	0.7352	0.7720	0.0735
8	R2	0.8823	0.8823	0.7352	0.7352	0.8088	0.0849
9	R3	10.4558	1.4705	1.4705	1.7647	3.7904	4.4457

Table 3.1.7: Concentrations of heavy metals in Bompai Industrial effluents

S/N	Sample	Cd (mg/dm^3)	Cr (mg/dm^3)	Cu (mg/dm^3)	Fe (mg/dm^3)	Pb (mg/dm^3)
1	S_1	2.9545±0.4545	1.1667±0.2886	1.7401±0.0938	3.0000±0.4000	0.4044±0.0735
2	S_2	2.7272±0.7422	3.1667±0.2886	2.6225±0.1470	4.1000±0.2000	0.9926±0.2511
3	S_3	3.8636±0.4545	4.6667±0.4714	1.0294±0.0566	2.6000±0.4000	0.7352±0.1200
4	M_1	1.8181±0.0000	1.8333±0.2886	1.3235±0.5574	2.7000±0.2000	0.6985±0.1407
5	M_2	2.9545±0.4545	4.1667±0.2886	3.6764±0.0980	2.0000±1.0832	1.0661±0.0735
6	M_3	3.8636±0.4545	7.1667±0.2886	1.6421±0.1470	3.2000±0.3265	2.2058±0.2079
7	R_1	2.0454±0.8703	3.3333±0.0000	0.7598±0.0490	2.1000±0.2000	0.7720±0.0735
8	R_2	3.4090±0.4545	4.6667±0.4714	1.6911±0.0938	4.1000±0.2000	0.8088±0.0849
9	R_3	2.0454±0.4545	7.3333±1.1547	2.0588±0.0800	2.7000±0.2000	3.7904±4.4457

Table 3.1.8: Mean and standard deviations of concentrations of heavy metals in Bompai Industrial effluents

S/N	Metal	Mean±Stdev (mg/dm^3)
1	Cadmium (Cd)	2.8535±0.7716
2	Chromium (Cr)	4.1667±2.1115
3	Copper (Cu)	1.8382±0.8799
4	Iron (Fe)	2.9444±0.7568
5	Lead (Pb)	1.2749±0.7716

Table 3.1.9: Permissible Levels (mg/dm^3) of heavy metals in effluents and waste water

S/N	Metal	FEPA [14]	W.H.O [15]
1	Cadmium (Cd)	1.0	NA
2	Chromium (Cr)	1.0	0.05
3	Copper (Cu)	1.0	0.5
4	Iron (Fe)	20	1.5
5	Lead (Pb)	1.0	1.0

Note:
NA: Data not available
FEPA: Federal Environmental Protection Agency, Nigeria
W.H.O: World Health Organisation.

3.2 DISCUSSION

3.2.1 P^H and conductivity values of Bompai industrial effluents.

The mean pH and conductivity values of the effluents are: (6.77±0.07) and (51.78±13.51) respectively. This shows that the effluents contained varying amounts of dissolved ions [2].

3.2.2 Concentrations of heavy metals in Bompai industrial effluents

3.2.2.1 Cadmium

The distribution pattern for cadmium in the effluents is shown in figure 3.1 with a mean of 2.8535 mg/l and standard deviation of 0.7716 mg/l. Samples S_3 and M_3 have the highest average cadmium concentrations. M_1 has the least average concentration of cadmium. The order of increase of average cadmium concentrations in the samples analysed is; $S_2 < S_1 < S_3$, $M_1 < M_2 < M_3$ and $R_1 = R_3 < R_2$.

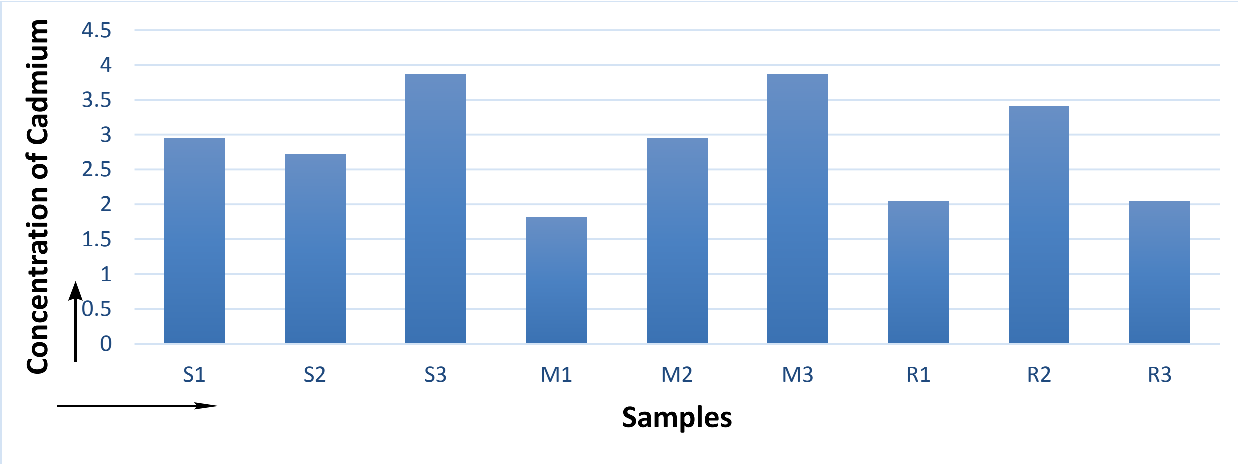

Figure 3.1: Variation of Cadmium in Bompai industrial effluents

3.2.2.2 Chromium

The distribution pattern for Chromium in the effluents is shown in figure 3.2 with a mean of 4.1667 mg/l and a standard deviation of 2.1115 mg/l. Sample R_3 has the highest average Chromium concentration while S_1has the lowest average concentration of Chromium. All the average value obtained are above the (FEPA, [14]) permissible level. The order of increase of Chromium in the samples analysed is; $S_1 < S_2 < S_3$, $M_1 < M_2 < M_3$and $R_1 < R_2 < R_3$.

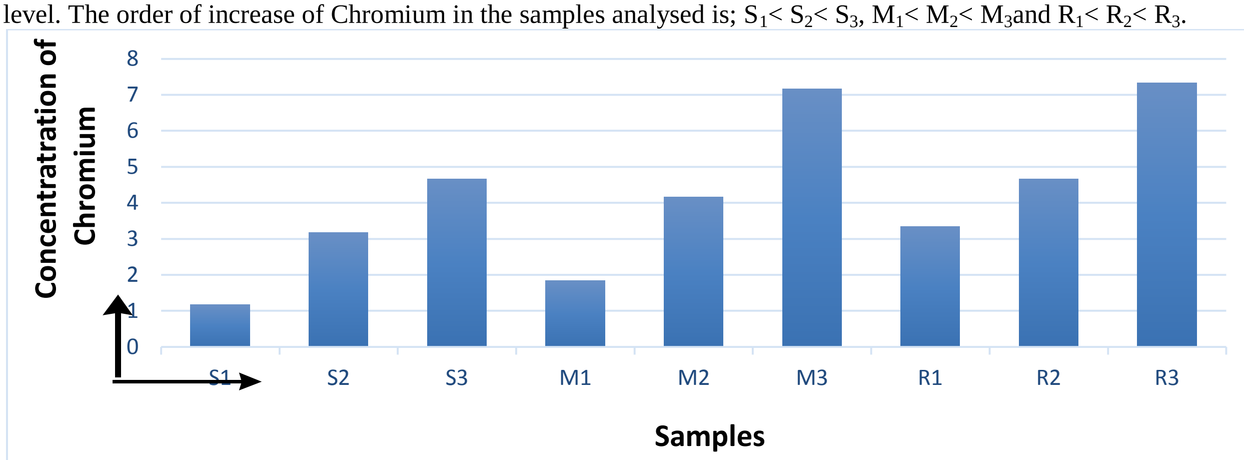

Figure 3.2: Variation of Chromium in Bompai industrial effluents

3.2.2.3 Copper

The distribution pattern for Copper in the effluents is shown in figure 3.3 with a mean of 1.8382 mg/l and a standard deviation of 0.8799 mg/l. Samples M_2 has the highest average copper concentration while R1 has the least average value. All the average values obtained are above the (W.H.O, [15]) permissible level. Only R_1 is below the (FEPA, [14]) permissible value.

The order of increase of average copper concentrations in the samples analysed is; $S_3 < S_1 < S_2$, $M_3 < M_1 < M_2$, and $R_1 < R_2 < R_3$.

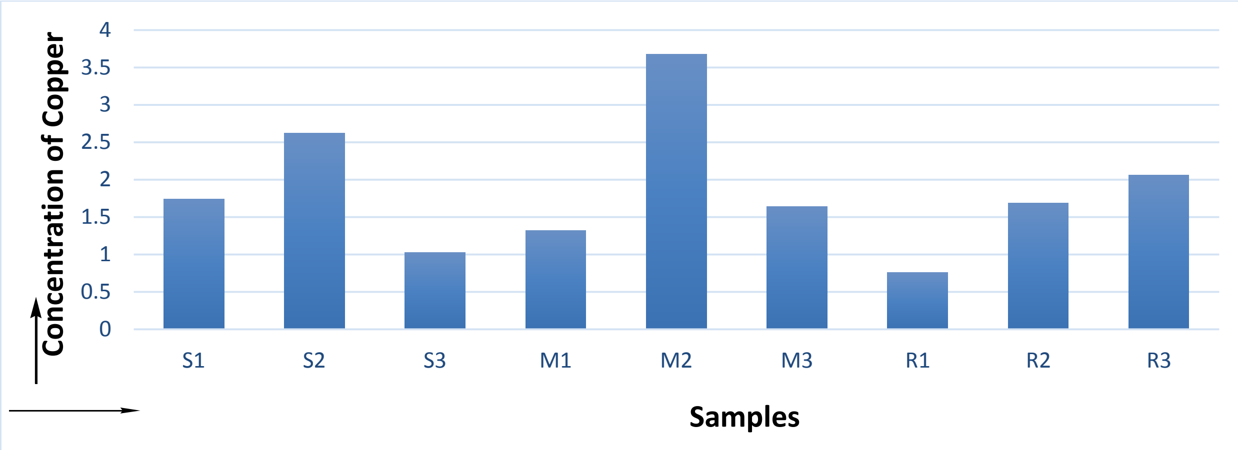

Figure 3.3: variation of copper in bompai industrial effluents

3.2.2.4 Iron

The distribution pattern for iron in the effluents is shown in figure 3.4 with a mean of 2.9444 mg/l and a standard deviation of 0.7568 mg/l. Samples S_2 and R_2 have the highest average Iron concentrations while M_2 has the lowest value. All the average value obtained are above the (W.H.O, [15]) permissible limit. Except M_2, all the average values are above (FEPA, [14]) permissible value. Average iron concentration increase in the order; $S_3 < S_1 < S_2$, $M_2 < M_1 < M_3$, and $R_1 < R_3 < R_2$.

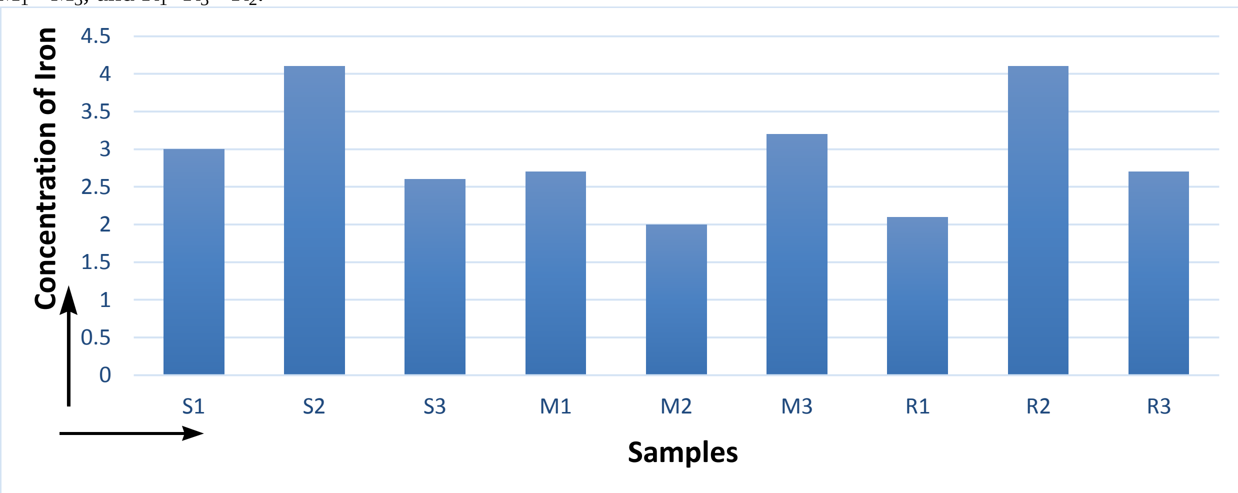

Figure 3.4: Variation of Iron in Bompai industrial effluents

3.2.2.5 Lead

The distribution pattern for Lead in the effluents is shown in figure 3.5 with a mean of 1.82749 mg/l and a standard deviation of 0.7716 mg/l. Sample R_3 has the highest mean lead concentration while S_1 has the least mean value. Only the average values of M_2, M_3 and R_3 are above the (FEPA, [14]) and (W.H.O, [15]) permissible limits. The order of increase of average Lead concentration is; $S_1 < S_3 < S_2$, $M_1 < M_2 < M_3$, and $R_1 < R_2 < R_3$.

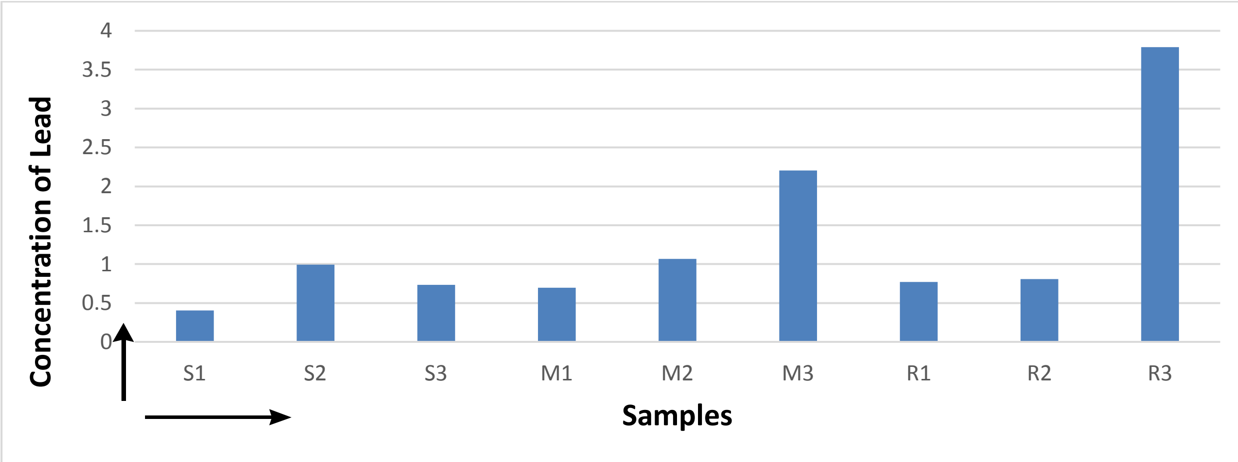

Figure 3.5: Variation of Lead in Bompai industrial effluents

4. Conclusion

Bompai industrial effluent sampled gave significant concentrations of Cadmium, Chromium, Copper, Iron, and Lead. Most of the values obtained are above the (FEPA, 1991) and (W.H.O, 1974) permissible limit, therefore, people residing in that area should avoid direct and indirect benefiting from the industrial effluent/wastewater in the area.

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