On Assessment of Heavy Metals in Water Sources of Peenya Industrial Area, Bengaluru, India

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***Abstract*:- Rapid industrialization and urbanization have recently become the need of the hour, for the countries like India. Levels of pollution are increasing beyond the prescribed limits as huge inputs of pollutants from the industries are entering the groundwater sources. The industries that induce the pollutants into the surface and groundwater sources from their activities do not strictly regulate their pollutant to safe limits. Many industries discharge their effluents without any treatment into nearby low lying areas or pass them through unlined drains, which move towards the depressions on land, resulting in the contamination of surface and groundwater sources. The industrial effluents, if not treated to remove or bring pollutant concentration level below standards specified, can pollute and cause serious damage to the water resources. The present study aims at assessing the heavy metal concentrations in water of Peenya industrial area, Bengaluru city. Water samples from 34 subsurface sources(bore wells and hand pumps) and 6 surface sources (tanks) in and around the industrial area were collected in March2013 and December 2013. Analytical procedures as described in the Standards were implemented for heavy metal analysis of these water samples and the results were compared with the permissible limits of heavy metals prescribed by Bureau of Indian Standards for drinking water(IS 10500), in order to evaluate the possibility of health hazards in the study area. The results reveal that most of the study area is highly polluted, because of the excessive concentration of one or more heavy metals like Nickel, Cadmium, Arsenic and Chromium, iron and copper. It is evident that water samples are non potable as per Bureau of Indian standards (IS 10500).**

Keywords: Industrial area, Pollutants, heavy metals, BIS standards, Potability.

I. Introduction

Industrialization has become essential for the economic development of the developing country like India. The major source of water pollution is release the effluents from industries. These effluents percolate into ground or flows into surface sources through damaged effluent storage tanks, damaged chemical storage tanks, damaged pipe lines, channels and damaged lining of drains. Some industries which are not having effluent treatment plants are disposing off their effluents into public sewers or open land in their premises itself. This activity of the industries results in increasing the water pollution. Some industries dump their solid wastes in open fields, which on decomposition releases the lechate which percolates into ground causing ground water pollution or flows into nearby surface sources. The study area considered is one of the largest industrial areas of Asia which houses nearly 2100 industries of different types. In the study area considered, people are using contaminated water for various purposes and are facing different types of health problems. Hence, the present study aims in the assessment of water quality and suggesting mitigative measures for the problems related to water pollution.

II. DETAILS OF STUDY AREA

2.1 Location

Bengaluru lies between North Latitude 12°52’21” to 13°6’0” and East Longitude 77°0’45” to 77°32’25” covering an area of approximately 800 sq.km. The study area is Peenya Industrial area, covering about 40 sq.km and lies to the North of Bengaluru on the national highway-4 and houses more than2100 industries dominated by chemical, leather, pharmaceutical, plating, polymer engineering and allied industries. This industrial area was established in late 1970s. The area is surrounded by residential houses and private industrial areas.

2.1.2. Climate

The mean annual rainfall over Bengaluru City is 860mm. Most of it is received during the southwest monsoon between June and September and during northeast monsoon. Statistically September is the wettest and January the driest month of the year. Air temperature varies between a minimum of 14°C and maximum of 34°C. The lowest temperature ever recorded was 7.8°C and the highest 38.9°C. April is the hottest month of the year while December to January marks the coldest period. The lowest relative humidity of 30% is noticed during the month of March and the highest between June and October, reaching up to 85%. Surface winds have seasonal character with westerly components predominating in July and easterly components in October. High-wind-speed averages of about 17 km/h during July under westerly winds and low-wind-speed averages to 8 to 9 km/h between April and October.

2.1.3. Soil, Geology and Drainage

Geologically, Peenya Industrial Area belongs to Achaean era. Gneiss, granite and dykes are the major rock types, the former two being found in varying depths. The area is nearly evenly flat with only gentle slopes and valleys. Predominantly red soil is found in the area overlaying granite and gneiss from which it is derived. The soil is moderately to severely eroded and excessively drained. It varies from gravelly to sandy with some clay here and there.

The drainage pattern is governed by granitic ridge, running north-northeast to south-southeast almost through the middle of the taluk. The eastern side of the drainage is made up of a network of nallas, flowing generally from west to east with storage tanks along the th, ultimately feeding the South Pinakini river on the western side. The western nallas generally flow from east to west, draining off into Arkavati river.

2.1.4. Topography

Topography of Bangalore is a ridge trending NNW–SSE. The Western part of the area is characterized by a dissected topography with ridges and valleys exposing hard rock, due to occurrence of rapid head-ward erosion of the Arkavathi River and its tributaries. The eastern part of the city is a level plain. The western part of the drainage of this ridge flows and joins the Arkavathi while the Eastern plains drain towards the South Pinakini**.** The highest point in the city is 924 m above Mean Sea Level near Triveni Engineering Works (Peenya Industrial Area) and the lowest around 800 m near Jevarana Doddi (Bangalore University).

2.1.5. Water bodies

Prominent water bodies in the vicinity of Peenya Industrial Area comprise of three tanks:Shivapura, Karihobanahalli and Dasarahalli. All the three tanks are lying downstream and are fed by a number of streams running through Peenya Industrial Area.

Fig.1 shows the location map of the study area

2.2. Details of Sampling Points

- Forty sampling points were selected in the study area, based on the hazardous ambient environment condition and the activities taking place around it.
- Out of 40 samples collected, 34 samples are from sub-surface sources (Bore wells and hand pumps,) and samples from No. 35 to 40 i.e., 6 samples are from surface sources (Tanks in and around the study area).
- The details of co-ordinates of each of the forty sampling points are as shown in Table.1

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III.METHODOLOGY

The samples collected from the study area are subjected to heavy metal analysis as per the standard methods. The heavy metals analysed include Iron, Copper, Nickel, Lead, Zinc, Cadmium, Arsenic and Chromium. The results obtained are compared with Standard values of permissible limits of heavy metals for drinking water prescribed in IS10500-1991.

IV.RESULTS OF ANALYSES

The samples collected from both surface and sub-surface sources are analyzed by using standard procedure for water and wastewater (APHA 2002).The results obtained were evaluated in accordance with the norms prescribed under 'Indian Standard Drinking Water Specification IS 10500. (1991) of Bureau of Indian Standards. The obtained results are tabulated in Tables 2 and 3. The results are graphically represented as shown in Fig.3 to Fig.10

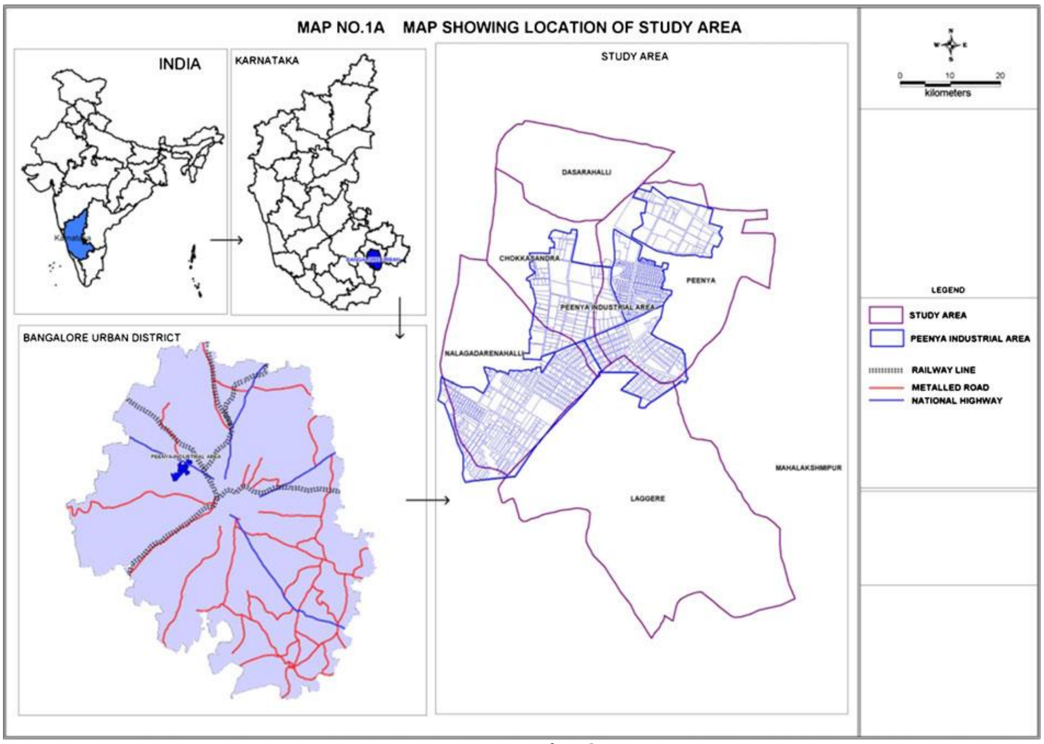

Fig.1. Location of study area

Table.1 Locations of water sampling sites

Sample station	Latitude	Longitude	Sample station	Latitude	Longitude
1	13°02'40.12"N	77° 31' 30.62"E	21	13º 01' 23.43"N	77º 29' 54.29"E
2	13°02'21.07"N	77° 31' 36.24"E	22	13º 01' 63.31"N	77º 29' 53.75"E
3	13°02'17.31"N	77° 31' 50.09"E	23	13º 01' 00.27"N	77º 29' 54.49"E
4	13°01'25.55"N	77° 31' 20.48"E	24	13º 01' 11.38"N	77º 30' 03.09"E
5	13°02'07.11"N	77° 30'30.56 "E	25	13º 06' 58.70"N	77º 30' 26.73"E
6	13°02'11.73"N	77° 30'35.64 "E	26	13º 02' 25.10"N	77º 30' 44.40"E
7	12°59'19.31"N	77° 29' 39.12"E	27	13º 02' 20.65"N	77º 30' 46.40"E
8	12°59'23.24"N	77° 29'38.03"E	28	13º 00' 42.33"N	77º 30' 30.51"E
9	13°00'38.78"N	77° 30'24.23"E	29	13º 01' 20.14"N	77º 30' 40.92"E
10	13°00'30.29"N	77° 30'19.99"E	30	13º 00' 48.08"N	77º 30' 52.52"E
11	13°00'30.03"N	77° 30'13.78"E	31	13º 01' 11.76"N	77º 31' 28.01"E
12	13°00'55.45"N	77° 30'17.34"E	32	13º 02' 33.79"N	77º 31' 52.78"E
13	13°00'50.25"N	77° 30'21.80"E	33	13º 02' 14.20"N	77º 31' 42.01"E
14	13°00'33.65"N	77° 30'14.86"E	34	13º 02' 19.19"N	77º 31' 39.72"E
15	13°01'30.49"N	77° 31'05.46"E	35	13º 02' 19.33"N	77º 32' 03.53"E
16	13°01'25.79"N	77° 31'05.28"E	36	13º 02' 25.89"N	77º 31' 18.24"E
17	13°02'16.39"N	77° 31'15.33"E	37	13º 02' 41.27"N	77º 31' 16.39"E
18	13°02'03.43"N	77° 30'44.29"E	38	13º 00' 46.51"N	77º 29' 05.12"E
19	13°01'39.08"N	77° 31'20.01"E	39	12º 59' 20.78"N	77º 29' 21.11"E
20	13°00'34.43"N	77° 31'29.93"E	40	12º 59' 27.43"N	77º 29' 35.91"E

Table. 2 Results of presence of heavy metals in water samples (pre monsoon)

Sample No.	Nickel mg/l	Lead mg/l	Zinc mg/l	Cadmium mg/l	Arsenic mg/l	Chromium mg/l	Iron mg/l	Copper mg/l
1	0.02	ND	3.335	0.003	0.005	ND	0.17	0.006
2	0.032	ND	7.4	0.004	ND	ND	0.172	0.009
3	0.001	ND	1.335	0.002	ND	ND	0.09	0
4	0.002	ND	1.66	0.013	ND	ND	0.06	0.022
5	0.019	ND	3.85	0.004	ND	ND	0.164	0.003
6	0.2	0.05	9.42	0.244	0.13	150	3.87	0.745
7	0.02	ND	11.4	0.009	ND	ND	0.4	0.013
8	0.026	ND	4.44	0.001	ND	ND	0.175	0.006
9	0.024	ND	4.64	0.007	ND	ND	0.55	0.005
10	1.678	ND	56.09	0.223	ND	ND	0.313	0.63
11	0.04	ND	4.06	0.001	ND	ND	0.35	0.005
12	0.08	ND	1.265	0.003	ND	ND	0.17	0.006
13	0.075	ND	1.123	0.013	0.051	1.9	3.9	0.005
14	0.07	ND	3.3	0.012	ND	ND	0.244	0.013
15	0.05	ND	9.178	0.014	ND	ND	0.3	0.02
16	0.108	ND	10.065	0.02	ND	ND	0.08	0.01
17	0.04	ND	0.905	0.001	ND	ND	0.075	0.004
18	0.042	ND	1.64	0.009	ND	ND	0.175	0.007
19	0.04	ND	11.65	0.01	ND	ND	0.1	0.006
20	0.06	ND	8.24	0.014	ND	ND	0.27	0.009
21	0.04	ND	0.72	0.02	ND	ND	0.215	0.009
22	0.042	ND	1.723	0.014	ND	ND	0.124	0.01
23	0.09	ND	4.55	0.001	ND	ND	0.289	0.01
24	0.045	ND	0.91	0.04	ND	ND	0.25	0.011
25	0.044	ND	1.305	0.02	ND	ND	0.65	0.013
26	0.05	ND	1.8	0.029	0.11	3.4	3	0.024

27	0.1	ND	1.76	0.02	0.02	2	4.2	0.03
28	0.04	ND	0.915	0.013	ND	ND	0.5	0.015
29	0.05	ND	0.86	0.02	ND	ND	0.601	0.03
30	0.034	ND	1.345	0.016	ND	ND	0.35	0.029
31	0.05	ND	1.295	0.025	ND	ND	0.572	0.01
32	0.04	ND	0.82	0.04	ND	ND	0.605	0.03
33	0.043	ND	0.19	0.002	ND	ND	0.397	0.009
34	0.045	ND	1.115	0.001	ND	ND	0	0.004
35	0.05	ND	4.445	0.006	0.005	3	6	0.014
36	0.053	ND	1.3	0.012	0.032	1.4	4	0.006
37	2.4	0.03	24	0.093	0.1	90	1.08	0.5
38	0.085	ND	1.855	0.1	0.11	24.5	3.7	0.155
39	0.06	ND	0.145	0.025	0.053	6.15	5	0.023
40	0.05	ND	0.4	0.006	0.23	4.45	7	0.002

(ND: Not Detected)

Table. 3 Results of presence of heavy metals in water samples (post monsoon)

Sample no	Nickel mg/l	Lead mg/l	Zinc mg/l	Cadmium mg/l	Arsenic mg/l	Chromium mg/l	Iron mg/l	Copper mg/l
1	0	0.17	0.098	0	0	0	0.03	0.1
2	0	0.16	0.16	0	0	0	0	0.01
3	0	0.16	0.141	0	0	0	0.11	0.02
4	0	0.14	0.092	0	0	0	0	0.04
5	0	0.15	0.148	0	0	0.8275	0.05	0.19
6	0	0.15	0.139	0	0	0	0.31	0.09
7	0	0.11	0.206	0	0	0.0068	0	0.52
8	0	0.11	1.878	0	0	0	0	0.06
9	0.109	0.11	0.092	0.026	0	0	0.16	0.36
10	0	0.12	0.115	0	0	0	0.01	0.17
11	0	0.12	0.111	0	0	0	0	0.6
12	0	0.12	0.098	0	0	0	0	0.73
13	0	0.13	0.103	0	0	0	0	0.58
14	0	0.11	0.089	0	0	0	0.3	0.69
15	0	0.08	0.094	0	0	0	0	0.44
16	0	0.1	0.102	0	0	1.4481	0.28	0.78
17	0	0.12	0.211	0	0	0	0	0.72
18	0	0.11	0.971	0	0	0	0.09	1.32
19	0	0.11	0.159	0	0	0	0	0.78
20	0	0.12	0.106	0	0	0	0.34	1.2
21	0	0.12	0.106	0	0	0	0.18	0.78
22	0	0.1	0.098	0	0	0	0.28	0
23	0	0.1	0.094	0	0	0	0.12	0.35
24	0	0.09	0.121	0	0	0.0393	0.06	0.89
25	0.008	0.14	0.125	0	0	0.2156	0	0.64
26	0	0.13	0.181	0	0	0	0.16	0.84
27	0	0.12	0.098	0	0	4.7925	0.18	0.65
28	0	0.12	0.09	0	0	0.2782	0.34	0.81
29	0	0.11	0.131	0	0	0.2337	0	0.51

30	0	0.12	0.656	0	0	0	0	0.72
31	0	0.12	0.137	0	0	0.0007	0	0.16
32	0	0.12	0.121	0	0	0.7193	0.26	0.83
33	0	0.13	0.098	0	0	0	0.79	0.61
34	0	0.09	0.387	0	0	0	0	0.83
35	0	0.09	0.649	0	0	0.0013	0.66	0.33
36	0	0.07	0.125	0	0	0	0.83	0.84
37	0.092	0.1	0.176	0	0	0.0212	0.69	0.55
38	0	0.1	0.102	0	0	0	0.79	0
39	0	0.08	0.09	0	0	0	0.54	0
40	0	0.11	0.252	0	0	0.0486	0.37	0

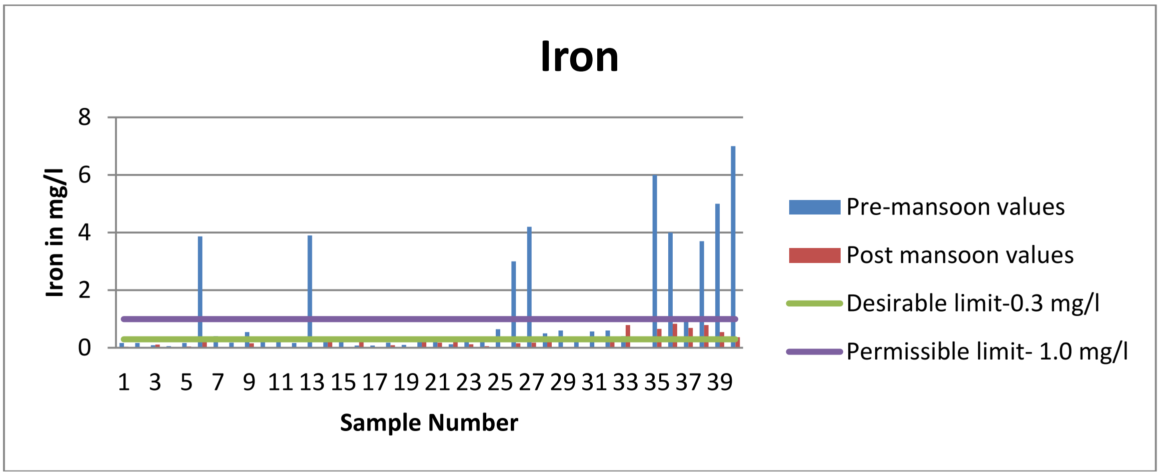

Fig.3 Seasonal variation of Iron in water samples

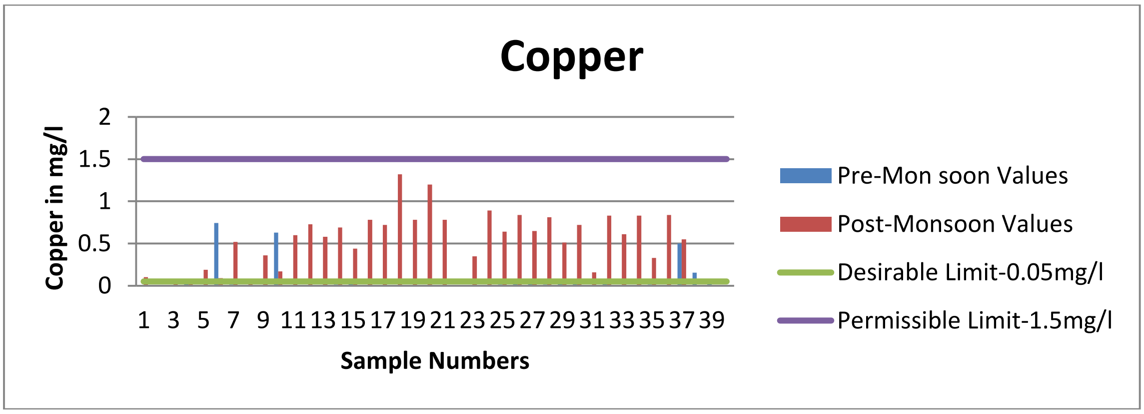

Fig.4 Seasonal variation of Copper in water samples

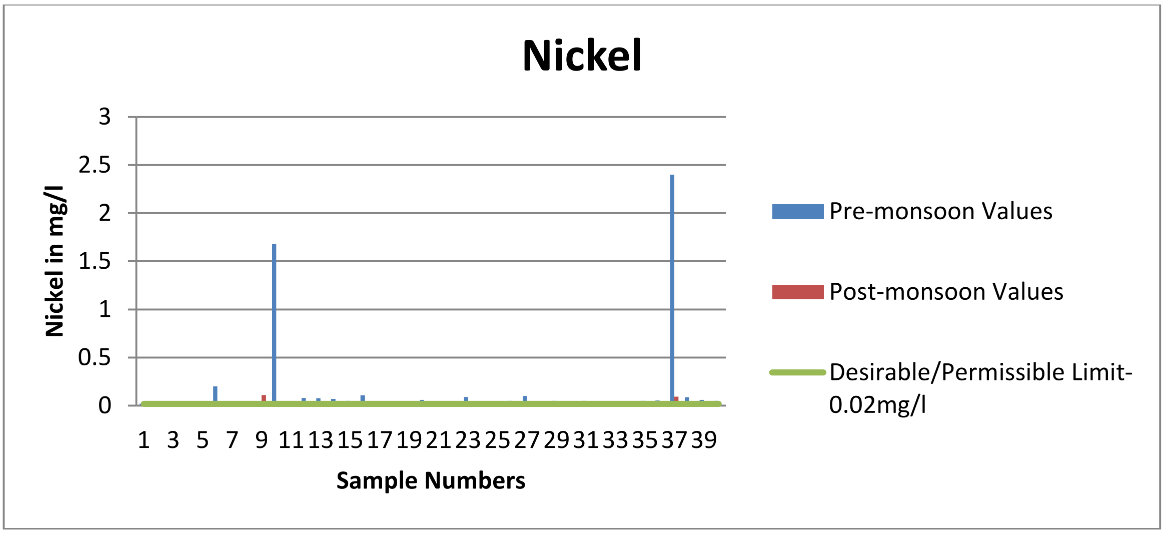

Fig.5 Seasonal variation of Nickel in water samples

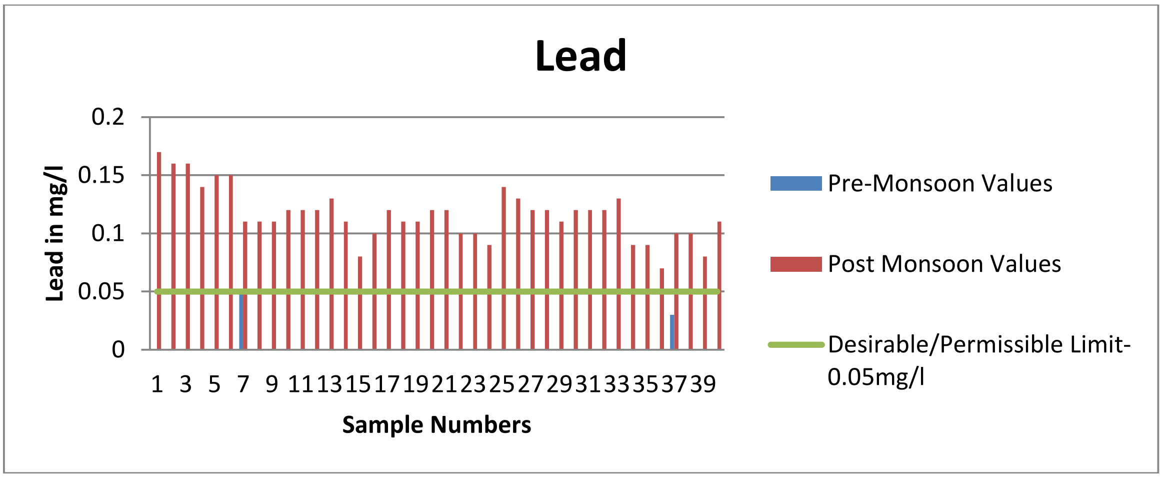

Fig.6 Seasonal variation of Lead in water samples

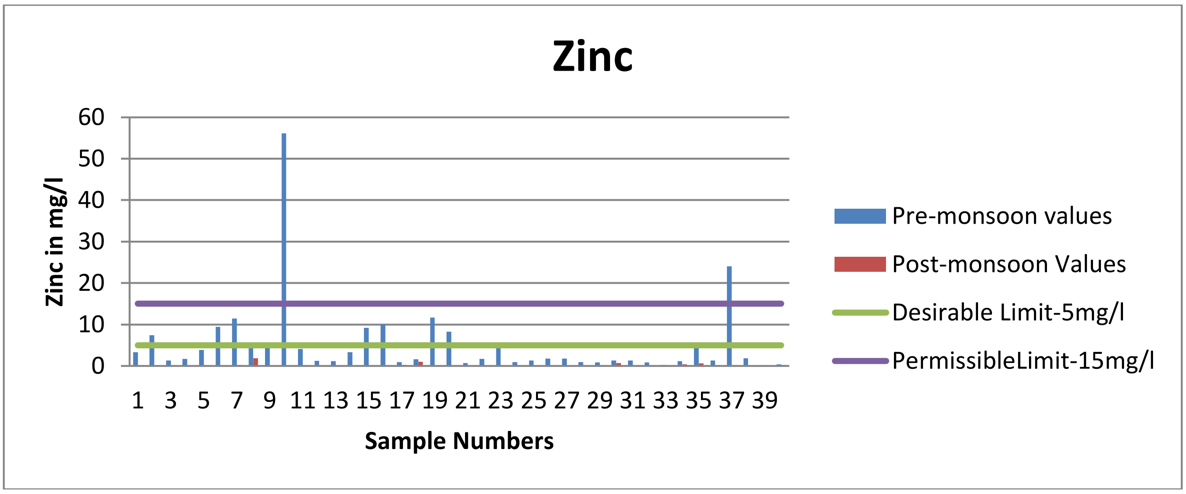

Fig.7 Seasonal variation of Zinc in water samples

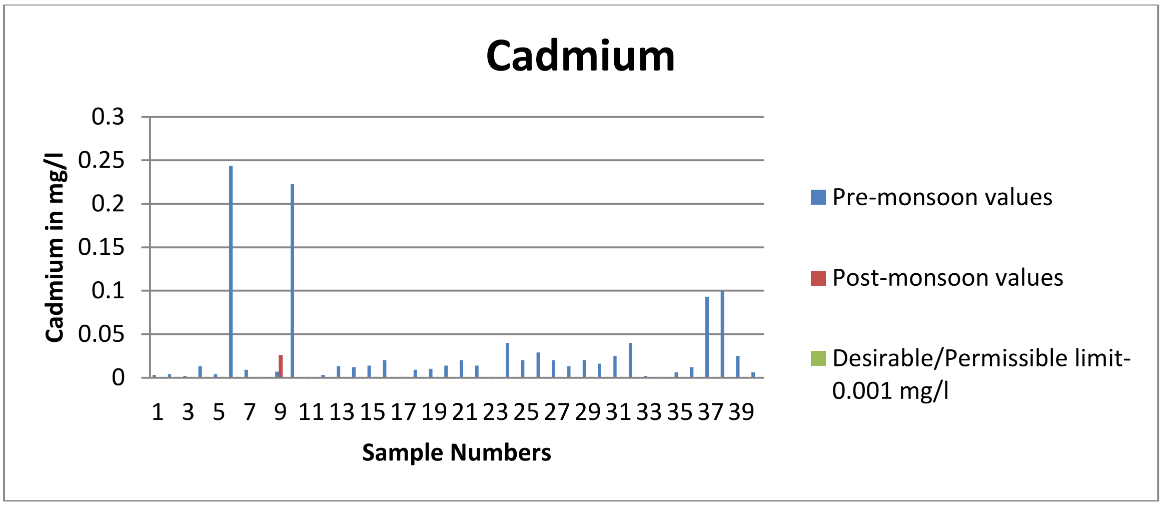

Fig.8 Seasonal variation of Cadmium in water samples

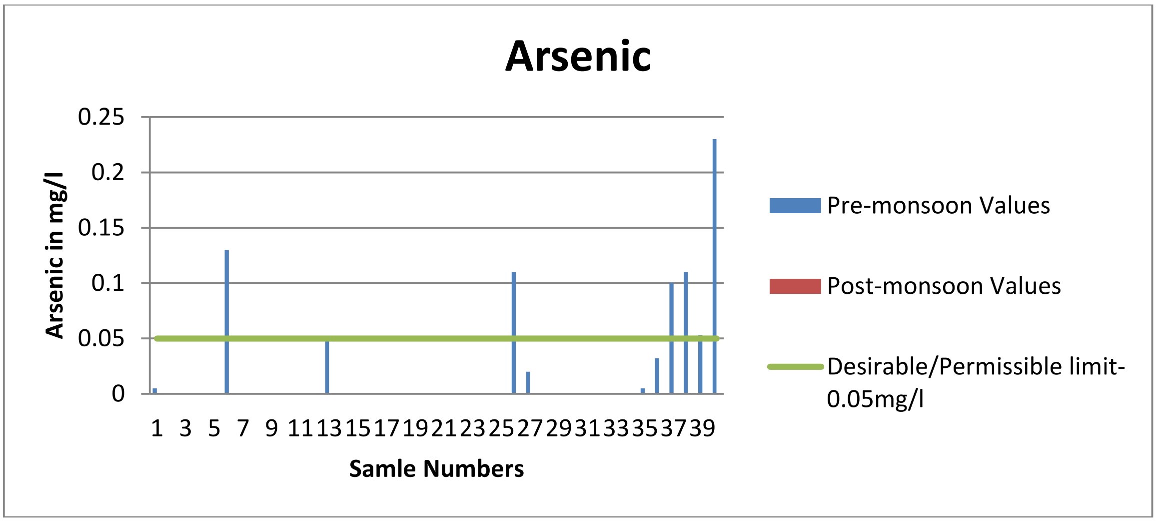

Fig.9 Seasonal variation of Arsenic in water samples

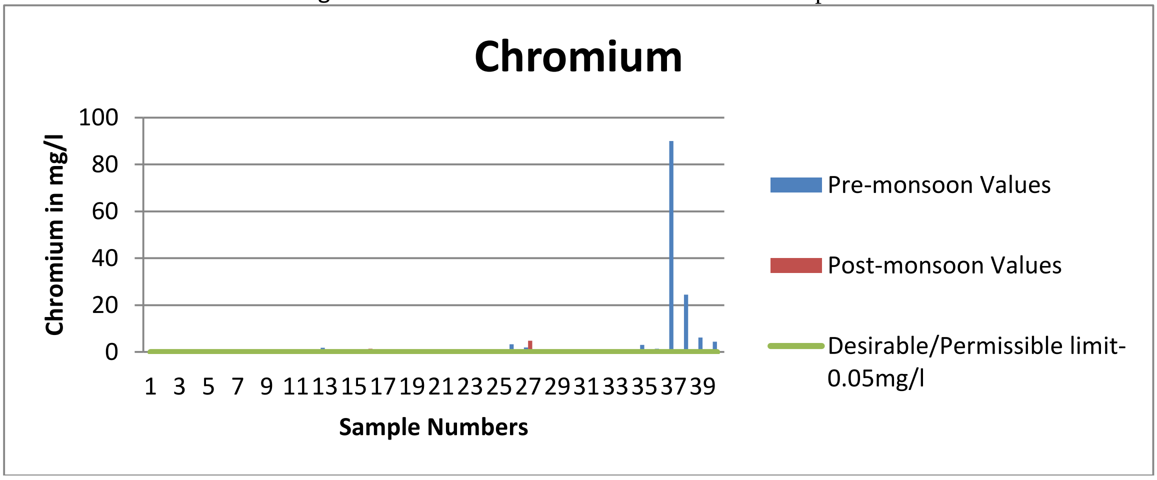

Fig.10 Seasonal variation of Chromium in water samples

V. DISSCUSSIONS OF RESULTS

Thirty four groundwater samples (1 to 34) were collected from the bore-wells and hand pumps and six other samples were collected from tanks in and around the study area (35 to 40).The results of chemical analyses are presented in Tables. 2 and 3. Table . 4 show the critical parameters along with the permissible limits for these parameters. Out of the 40 samples analyzed for heavy metals, all 40samples (100%) were found to be non-potable. The main heavy metals constituting for the non -potability of the samples are iron ,Nickel, lead Cadmium and Chromium which accounted for 25%, 95%, 100% , 87.5% and 25% of unsafe samples respectively.

Table 4: Critical parameters of water as per IS: 10500(1991)

SL. No	Parameter (mg/l)	Desirable limit	Permissible limit	Number of samples exceeding Permissible limits		Percentage of samples Exceeding the Permissible limits.	
				Pre monsoon	Post monsoon	Pre monsoon	Post monsoon
1	Iron	0.3	1	10	0	25	0
2	Nickel	0.02	No relaxation	38	2	95	5
3	Lead	0.05	No relaxation	0	40	0	100
4	Zinc	5	15	2	0	5	0
5	Copper	0.05	1.5	0	0	0	0
6	Cadmium	0.001	No relaxation	35	1	87.5	2.5
7	Arsenic	0.05	No relaxation	4	0	10	0
8	Chromium	0.05	No relaxation	10	6	25	15

1. Iron : Iron has adverse effect on domestic uses of water and water supply structures, and promotes iron bacteria which forns brown slimy layer in pipes. In most of the surface water samples Iron value is very high, hence use of water with high iron will cause adverse effects like unpleasant metallic taste ,warding of fatigue and anemia.
2. Copper : Beyond the desirable limit Copper causes a stringent taste, discoloration of water and corrosion of pipes, fittings and utensils. Too much copper can cause adverse ill effects, including vomiting, diarrhea, stomach cramps and nausea. It is also be en associated with liver damage and kidney disease.
3. Nickel :. Beyond the permissible limit Nickel may cause allergic reaction. Exposure to skin can cause dermatitis upon contact.
4. Lead : Beyond the permissible limit , Lead makes water toxic. Lead is associated with a wide range of effects, including various neuro developmental effects, mortality (mainly due to cardiovascular diseases), impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes. Impaired neurodevelopment in children is generally associated with lower blood lead
concentrations than the other effects,
5. Zinc : Beyond the permissible limit Zinc can cause a stringent taste and an opalescence in water. The effects of zinc toxicity are upset stomach, vomiting and diarrhea .
6. Cadmium : Beyond the permissible limit , Cadmium makes water toxic. With chronic oral exposure it effects the kidney .
7. Arsenic : Beyond the permissible limit , Arsenic makes the water toxic. Long term exposure to arsenic in drinking water can cause cancer in the skin , lungs, bladder and kidney. It can also cause skin changes such as thickening and pigmentation.
8. Chromium :Beyond the permissible limit Chromium makes water toxic. Too much exposure can be hazardous causing nose irritation that results in runny nose, nose bleeds, ulcers, open sores around the stomach lining and nasal symptoms.

VI. CONCLUSIONS

The analyses of groundwater and the surface water samples from the Peenya industrial area has shown that almost 90% of the samples are unfit for drinking purpose. The analyzed data clearly indicates that the Pb is generally present in GW samples due to plumbing accessories and industrial waste. At few locations, Cu, Cr, Fe and Cd concentrations could be high due to disposal of electroplating and dye industrial waste. Groundwater is getting polluted at an alarming rate due to rapid industrialization. The investigations and oral discussions held with the health centre officials and general public of the area, clearly points out that the serious contamination of the groundwater and surface water in the vicinity of the industries and ill-health faced by the localities. From the perspective of improving the quality of groundwater and surface water in the area and protecting the people from the troubles of groundwater and surface water contamination, it is absolutely essential to initiate measures to check the pollution of industrial effluents through strict enforcement of legislation for industries, setting up of effluent treatment plants. Replacing of the damaged pipelines and repairing lining of sewers is necessary to prevent the leakage of sewage in pipes and seepage through unlined channels and to prevent the mixing or leaking of sewage with groundwater. Water treatment facility shall be designed in order to provide potable water to the residents of the area. This study is carried out during pre monsoon season. Further this study can also carried out during monsoon also.

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