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Assessment of Heavy Metals Concentration and Groundwater Quality in Peenya Industrial Area

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Abstract: The objective of this study is to determine the heavy metals concentration and groundwater quality in peenya industrial area. Peenya is one of the biggest industrial areas in Asia, which is known for engineering and electrical goods. Hence this study is aimed at determining heavy metal concentrations and quality of groundwater. For analysis 30 samples were collected from the selected area at different locations and analysed for various physical and chemical parameters. Such as pH, electrical conductivity, chloride, calcium, total hardness, total dissolved solids, fluoride, nitrate sulphates and sodium were determined in laboratory using analytical and method. And heavy metals such as copper, cadmium, mercury, arsenic, chromium, nickel and zinc were analysed using AAS (Atomic Absorption Spectrophotometer). Spatial distribution maps were prepared using **Qgis** software that represents concentrations of various physiochemical parameters and heavy metals at different sampling locations. The present study reveals that groundwater of the study area needs particular degree of treatment to reduce future contamination.

Keywords: Groundwater quality, heavy metals, industrial area.

INTRODUCTION

Groundwater is the water beneath earth's surface, and is often cheaper, more convenient and less vulnerable to pollution like surface water depending on surrounding environment. The polluted groundwater is less visible and more difficult to clean up. It is widely used for domestic, agricultural and industrial purposes. The groundwater in Karnataka is highly contaminated with almost all 30 districts in state showed fluoride and nitrate contents, as for our study area is concerned the contaminants include even heavy metals also as it is industrial area. According to Central groundwater board more than 85% of India's rural domestic water requirements, 50% of urban and 50% of its irrigation requirements are being met from ground water resources. The increasing dependence on groundwater due to increasing population as resulted in overexploitation of groundwater sources, impacts of which can be seen in the form of long term decline of groundwater levels, de-saturation of aquifers, quality deterioration, increased energy consumption to lift water from deeper levels.

Heavy metals are group of metals or metalloids that have relatively high density and toxic at low concentrations. Industries, agricultural activities, pharmaceutical and mining are anthropogenic sources and some metal bearings rocks are natural sources of heavy metals in environment. Due to mining, acid runoff, infiltration, runoff from agricultural fields containing fertilizers, heavy metals enters into groundwater making it toxic and unfit for human consumption and other purposes. Heavy metals are non-biodegradable which causes 'Bio-accumulation' and enters the food chain leading to serious health problems. So it becomes important to assess the concentrations of heavy metals and other water quality parameters.

I. STUDY AREA

Peenya industrial area is located on the north-western suburbs of Bangalore city between latitude 13°1'42" N and longitude 77°30'45" E and Bangalore is located at a latitude of 12°58' N and longitude of 77°35' E. The industrial area was established in late 1970s by Karnataka small industries Development Corporation as Stage 1, 2 and 3 later on Karnataka Industrial Area Development Board developed it as phase 1, 2, 3 and recently 4. More than 2100 industries are located here that includes small, medium and large scale industries, which is known for engineering and electrical goods like CNC Machine tools, fabrications, GDC dies and moulds transformers, hydraulics, machine tools, textile and rubber moulding industries. Peenya is one of the biggest industrial areas in south East Asia and spread over 40 square-kilometre areas. Terrain is highly undulating with red sandy soil which extends up to 1-2 meters below the ground level.

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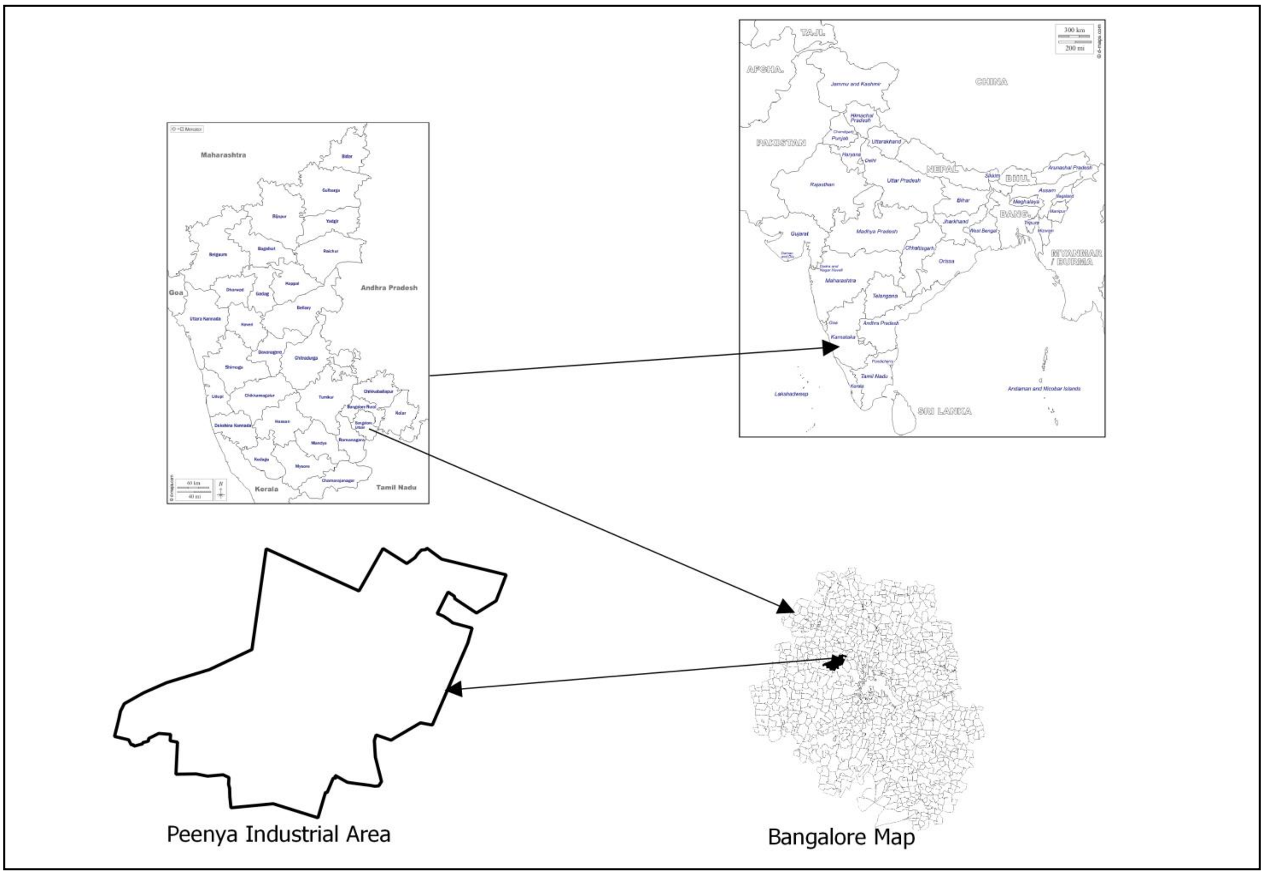

Fig 1 Study area map

II. METHODOLOGY

Groundwater samples were collected in containers of 1 litre capacity from 30 different locations inside peenya industrial area. Figure 2 sows the sampling locations in the study area.

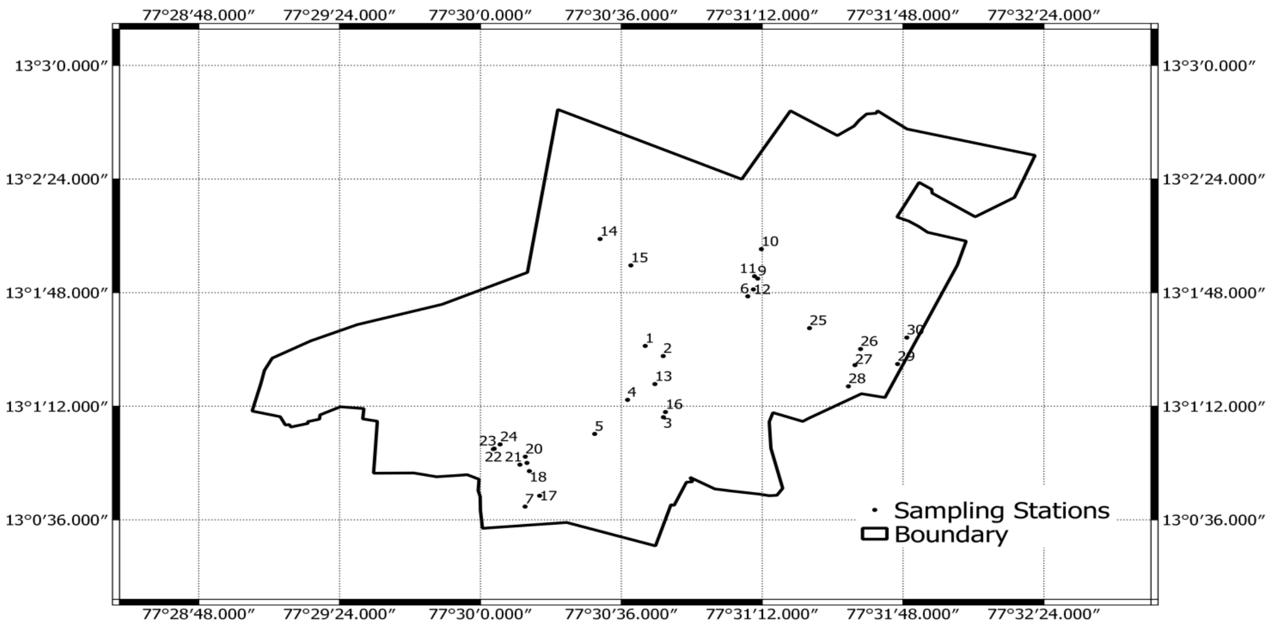

Fig 2 Groundwater sampling locations

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The samples were analysed for physiochemical parameters such as pH, chlorides, fluorides, nitrate, sodium, sulphates, electrical conductivity, TDS, total hardness and calcium were determined using analytical method and heavy metals such as copper, nickel, chromium, cadmium, mercury, zinc and arsenic by AAS. Using these parameters groundwater quality was computed.

GIS mapping was done using 'Qgis' software, showing spatial distribution of all parameters including heavy metals.

III. RESULTS AND DISCUSSION

Variation of heavy metals concentration in groundwater

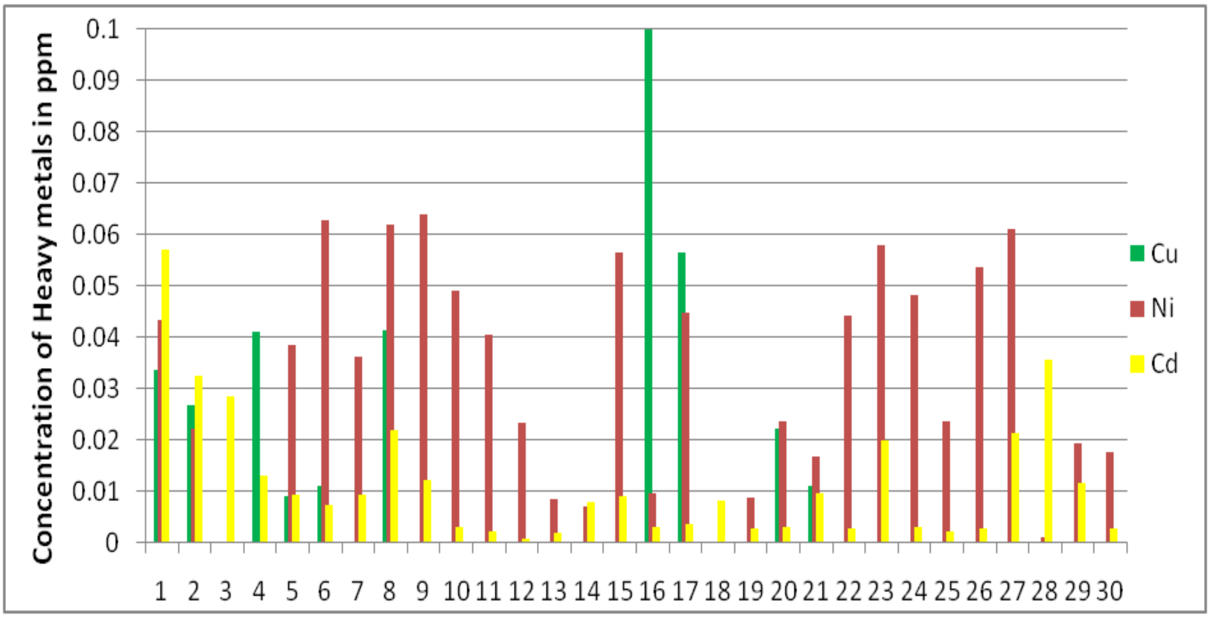

Fig 3

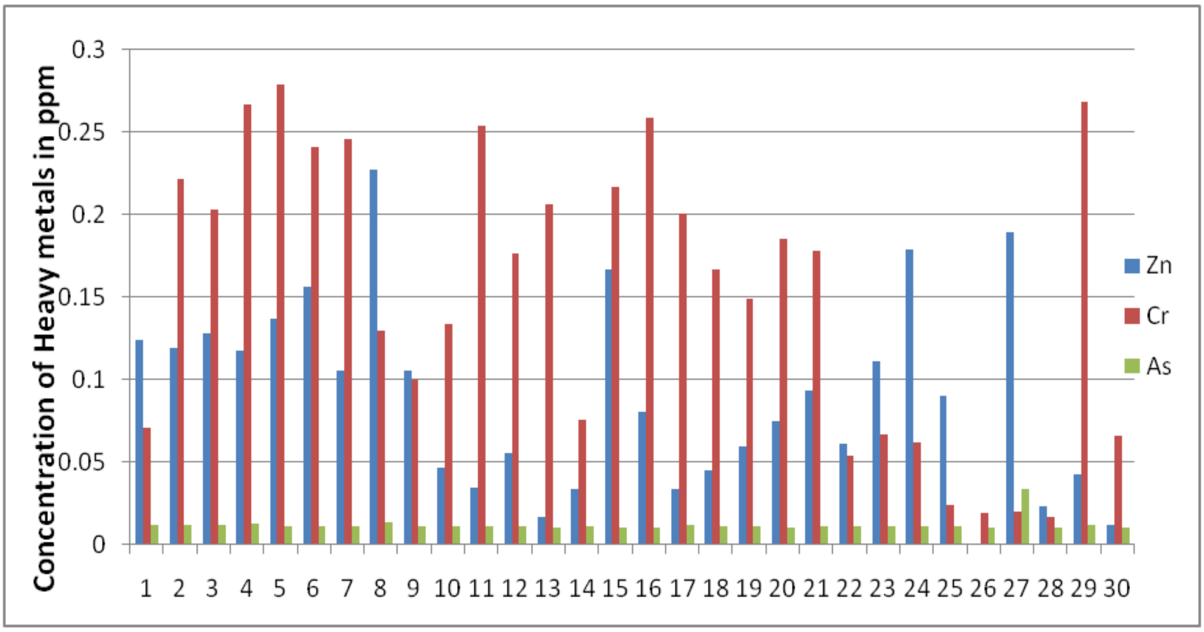

Fig 4

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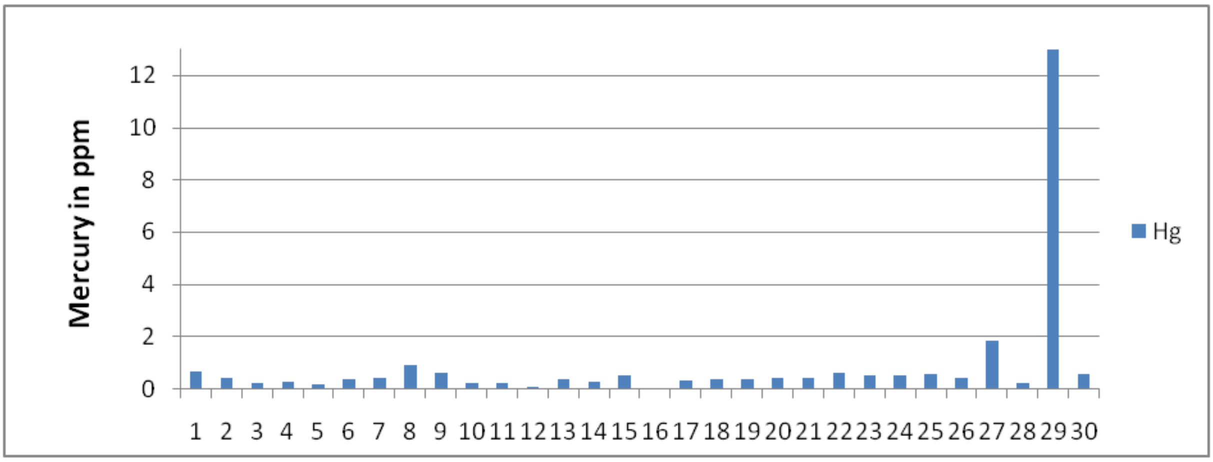

Fig 5

Table 1. Heavy metals concentrations in groundwater in study area in mg/l

Station	Latitude	Longitude	Copper	Nickel	Cadmium	Zinc	Chromium	Arsenic	Mercury
1	13°01'31.1" N	77°30'42.1" E	0.03357	0.04328	0.0572	0.1244	0.07088	0.01234	0.6462
2	13°01'27.5" N	77°30'46.6" E	0.02673	0.0223	0.03263	0.119	0.2219	0.01194	0.4119
3	13°01'08.5" N	77°30'46.8" E	-	-	0.02859	0.1279	0.203	0.01219	0.2393
4	13°01'14.0" N	77°30'37.6" E	0.04127	-	0.01326	0.1175	0.2669	0.01274	0.2867
5	13°01'03.2" N	77°30'29.2" E	0.00902	0.03844	0.009398	0.1372	0.2788	0.01117	0.1783
6	13°01'46.8" N	77°31'08.3" E	0.01104	0.06272	0.00743	0.1564	0.241	0.01124	0.3876
7	13°00'40.2" N	77°30'11.4" E	-	0.03641	0.009517	0.1057	0.2456	0.01109	0.4141
8	13°01'12.3" N	77°29'52.3" E	0.04153	0.06206	0.02199	0.2273	0.1297	0.01367	0.892
9	13°01'52.4" N	77°31'10.9" E	-	0.06409	0.01225	0.1055	0.09967	0.01091	0.6262
10	13°02'01.8" N	77°31'11.8" E	-	0.04924	0.003	0.04646	0.1338	0.01134	0.2369
11	13°01'53.2" N	77°31'10.1" E	-	0.04053	0.002155	0.03447	0.2539	0.01124	0.2346
12	13°01'49.0" N	77°31'09.8" E	-	0.02353	0.000736	0.05576	0.1769	0.01105	0.06427
13	13°01'19.0" N	77°30'44.6" E	-	0.008579	0.001931	0.01654	0.2065	0.01077	0.3565
14	13°02'05.0" N	77°30'30.6" E	-	0.007232	0.007974	0.03387	0.07594	0.01158	0.2639
15	13°01'56.6" N	77°30'38.4" E	-	0.05644	0.009048	0.167	0.2171	0.01078	0.5026
16	13°01'10.9" N	77°30'46.1" E	0.1361	0.009691	0.003153	0.08087	0.2585	0.01041	0.006897
17	13°00'43.6" N	77°30'15.1" E	0.0565	0.04476	0.003766	0.03347	0.2007	0.01185	0.3368

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18	13°00'51.4" N	77°30'12.5" E	-	-	0.008254	0.04497	0.1672	0.01134	0.3789
19	13°00'54.0" N	77°30'11.9" E	-	0.008748	0.002978	0.05967	0.1493	0.01093	0.3472
20	13°00'56.0" N	77°30'11.5" E	0.02217	0.02381	0.003189	0.07526	0.1853	0.01044	0.4258
21	13°00'53.5" N	77°30'10.1" E	0.01126	0.01671	0.009684	0.09347	0.1786	0.01142	0.4196
22	13°00'58.4" N	77°30'03.3" E	-	0.04431	0.002858	0.06095	0.05414	0.01091	0.6068
23	13°00'58.5" N	77°30'03.5" E	-	0.05813	0.01991	0.1116	0.06702	0.01095	0.5379
24	13°00'59.9" N	77°30'05.0" E	-	0.04836	0.003232	0.1791	0.06221	0.01139	0.5357
25	13°01'36.7" N	77°31'24.1" E	-	0.02373	0.002164	0.09046	0.02434	0.01094	0.565
26	13°01'30.1" N	77°31'37.2" E	-	0.05373	0.002707	-	0.019	0.0106	0.4165
27	13°01'25.0" N	77°31'35.7" E	-	0.06125	0.02137	0.1893	0.02001	0.0341	1.854
28	13°01'18.3" N	77°31'34.1" E	-	0.001013	0.03567	0.02362	0.01702	0.01061	0.2108
29	13°01'25.4" N	77°31'46.6" E	-	0.01955	0.01161	0.04277	0.2685	0.01197	13.01
30	13°01'33.7" N	77°31'49.0" E	-	0.01782	0.002926	0.01236	0.06594	0.01035	0.5734

Table 2. Physiochemical parameters in study area

Station	Latitude	Longitude	pH	Conductivity (µs/cm)	TDS (mg/l)	Chloride (mg/l)	Calcium (mg/l)
1	13°01'31.1"N	77°30'42.1"E	8.07	1452	948	73.87	144
2	13°01'27.5"N	77°30'46.6"E	7.839	1337	850	287.5	291
3	13°01'08.5"N	77°30'46.8"E	7.578	1045	698	205.64	241
4	13°01'14.0"N	77°30'37.6"E	7.631	1195	762	249.57	333
5	13°01'03.2"N	77°30'29.2"E	6.345	1021	684	241.58	235
6	13°01'46.8"N	77°31'08.3"E	5.091	1303	818	267.53	323
7	13°00'40.2"N	77°30'11.4"E	6.456	1381	891	181.68	227
8	13°01'12.3"N	77°29'52.3"E	6.444	1236	1580	185.68	250
9	13°01'52.4"N	77°31'10.9"E	6.571	1009	679	379.34	346
10	13°02'01.8"N	77°31'11.8"E	6.84	840	569	221.61	218
11	13°01'53.2"N	77°31'10.1"E	7.08	833	533	129.77	124
12	13°01'49.0"N	77°31'09.8"E	7.245	362	240	349.39	274
13	13°01'19.0"N	77°30'44.6"E	6.891	1037	649	229.6	237
14	13°02'05.0"N	77°30'30.6"E	6.963	979	618	293.49	263
15	13°01'56.6"N	77°30'38.4"E	6.965	1224	842	185.68	195

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16	13°01'10.9"N	77°30'46.1"E	7.047	1131	723	281.51	267
17	13°00'43.6"N	77°30'15.1"E	7.088	1013	654	377.34	356
18	13°00'51.4"N	77°30'12.5"E	7.122	890	584	291.49	217
19	13°00'54.0"N	77°30'11.9"E	7.65	913	585	323.44	267
20	13°00'56.0"N	77°30'11.5"E	7.64	1366	858	331.42	291
21	13°00'53.5"N	77°30'10.1"E	7.75	1312	824	708.77	482
22	13°00'58.4"N	77°30'03.3"E	7.7	1074	746	351.39	276
23	13°00'58.5"N	77°30'03.5"E	7.75	1957	979	575	433
24	13°00'59.9"N	77°30'05.0"E	7.8	1326	821	439.24	313
25	13°01'36.7"N	77°31'24.1"E	7.89	1042	654	333.42	321
26	13°01'30.1"N	77°31'37.2"E	7.88	1134	745	614.94	387
27	13°01'25.0"N	77°31'35.7"E	8.146	6350	3960	259.55	193
28	13°01'18.3"N	77°31'34.1"E	7.43	705	466	217.62	228
29	13°01'25.4"N	77°31'46.6"E	7.93	1059	711	469.19	362
30	13°01'33.7"N	77°31'49.0"E	7.99	2240	1392	109.81	1321

Station	Latitude	Longitude	Sodium (mg/l)	Nitrate (mg/l)	Fluoride (mg/l)	Sulphate (mg/l)	Total Hardness (mg/l)
1	13°01'31.1"N	77°30'42.1"E	41	3.8	0.064	21.46	200
2	13°01'27.5"N	77°30'46.6"E	53	38	0.031	24.41	608
3	13°01'08.5"N	77°30'46.8"E	58	80	0.071	21.72	808
4	13°01'14.0"N	77°30'37.6"E	71	90	0.034	20.47	668
5	13°01'03.2"N	77°30'29.2"E	71	48	0.105	23.93	708
6	13°01'46.8"N	77°31'08.3"E	82	116	0.035	26.17	608
7	13°00'40.2"N	77°30'11.4"E	90	13	0.049	18.69	492
8	13°01'12.3"N	77°29'52.3"E	99	41	0.053	17.94	480
9	13°01'52.4"N	77°31'10.9"E	106	37	0.038	20.11	764
10	13°02'01.8"N	77°31'11.8"E	113	31	0.056	24.96	528
11	13°01'53.2"N	77°31'10.1"E	113	217	0.074	32.59	408
12	13°01'49.0"N	77°31'09.8"E	119	54	0.074	22.66	820
13	13°01'19.0"N	77°30'44.6"E	119	72	0.101	21.18	476
14	13°02'05.0"N	77°30'30.6"E	120	102	0.041	25.26	556

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15	13°01'56.6"N	77°30'38.4"E	126	47	0.058	22.7	424
16	13°01'10.9"N	77°30'46.1"E	130	89	0.049	20.92	540
17	13°00'43.6"N	77°30'15.1"E	135	16	0.033	29.69	748
18	13°00'51.4"N	77°30'12.5"E	146	60	0.044	28.82	516
19	13°00'54.0"N	77°30'11.9"E	156	152	0.105	23.32	704
20	13°00'56.0"N	77°30'11.5"E	160	103	0.076	23.88	568
21	13°00'53.5"N	77°30'10.1"E	171	70	0.079	24.14	452
22	13°00'58.4"N	77°30'03.3"E	171	128	0.23	21.82	332
23	13°00'58.5"N	77°30'03.5"E	179	8.7	0.045	29.92	776
24	13°00'59.9"N	77°30'05.0"E	189	73	0.074	20.49	948
25	13°01'36.7"N	77°31'24.1"E	195	47	0.052	32.47	684
26	13°01'30.1"N	77°31'37.2"E	204	47	0.11	20.77	1012
27	13°01'25.0"N	77°31'35.7"E	204	178	0.143	26.64	512
28	13°01'18.3"N	77°31'34.1"E	259	72	0.173	24.11	536
29	13°01'25.4"N	77°31'46.6"E	280	223	0.044	24.59	608
30	13°01'33.7"N	77°31'49.0"E	1051	80	0.018	22.46	1740

Maps showing spatial distribution of heavy metals and physiochemical parameters in the study area

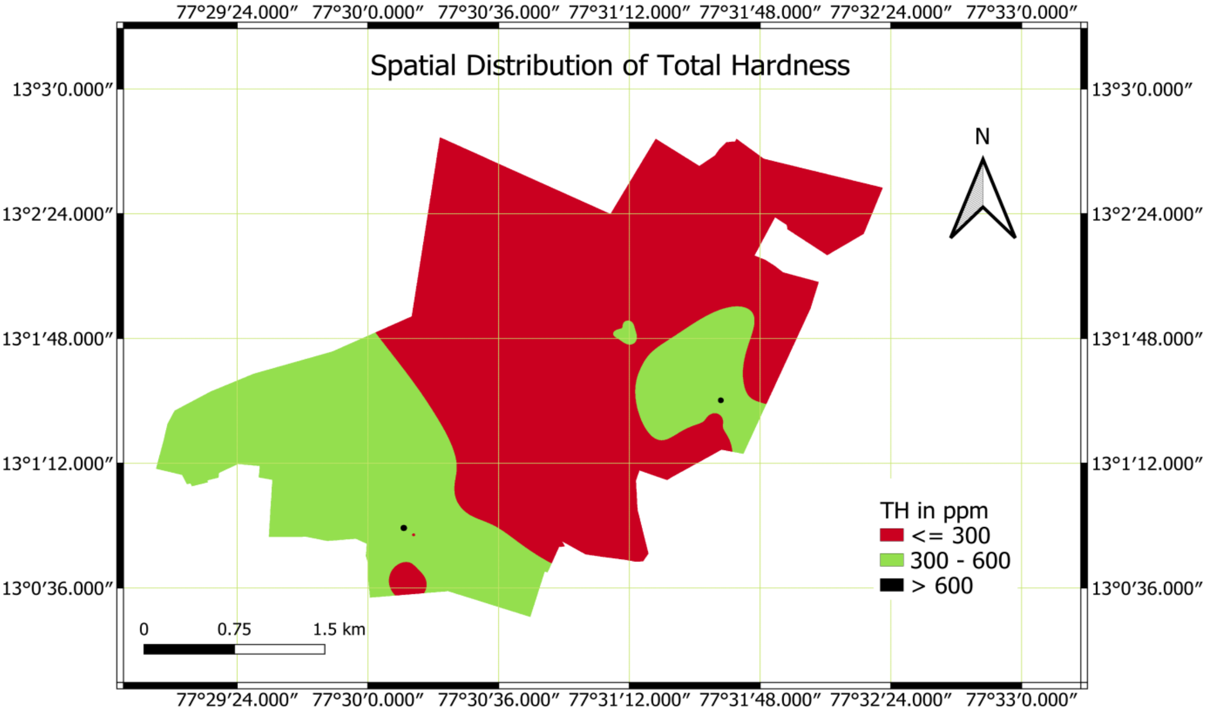

Fig 6

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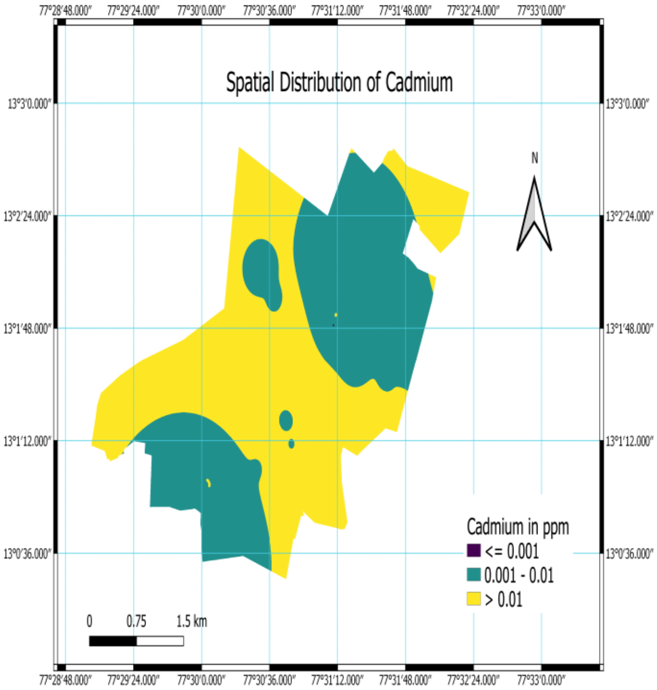

Fig 7

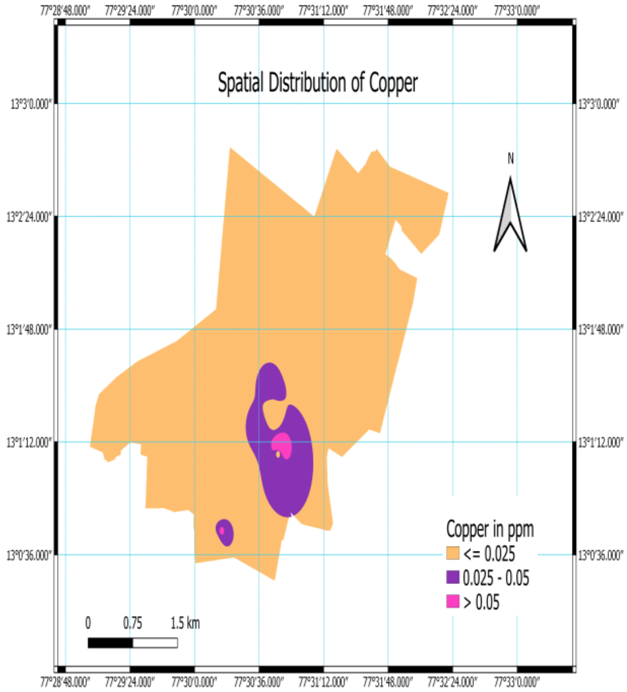

Fig 8

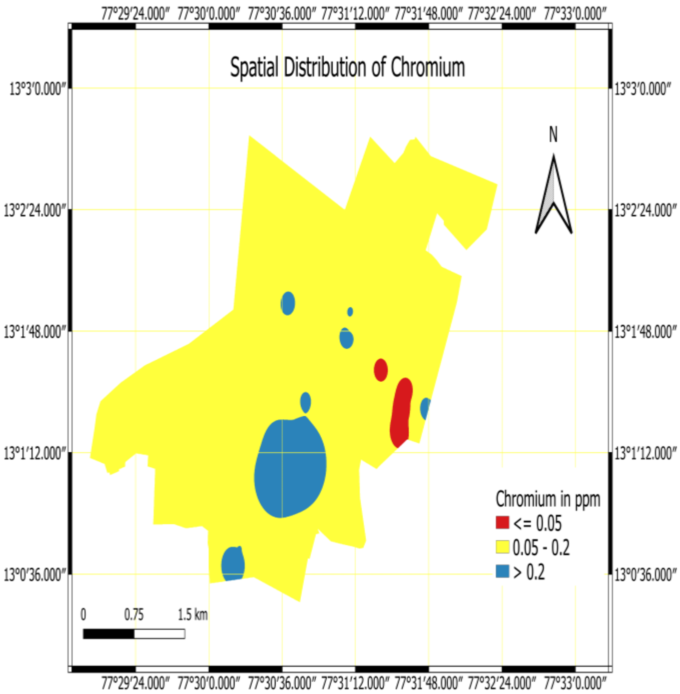

Fig 9

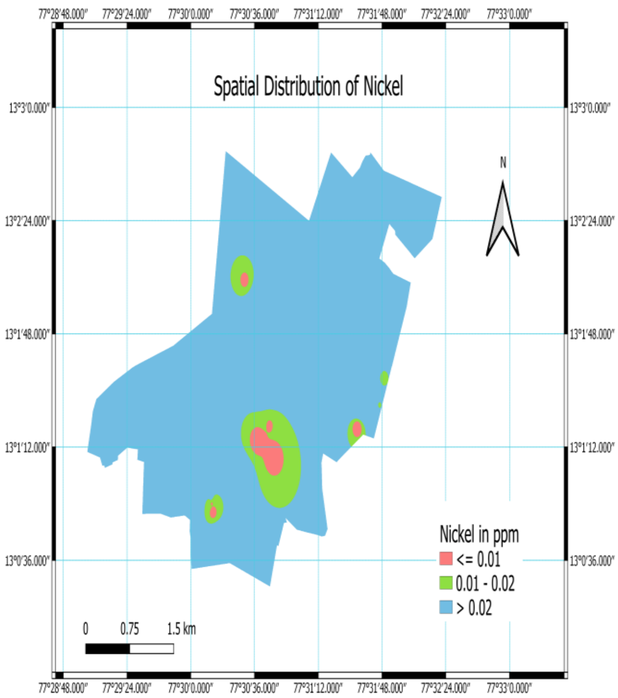

Fig 10

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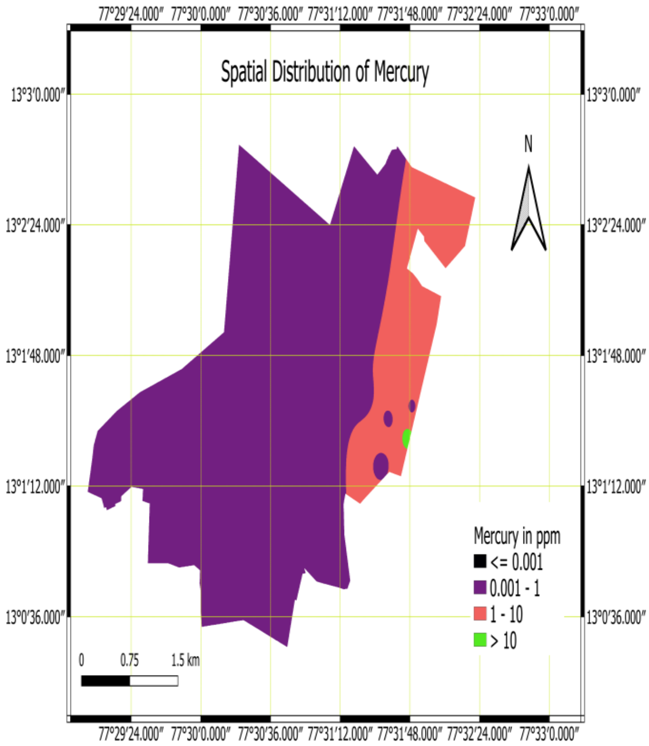

Fig 11

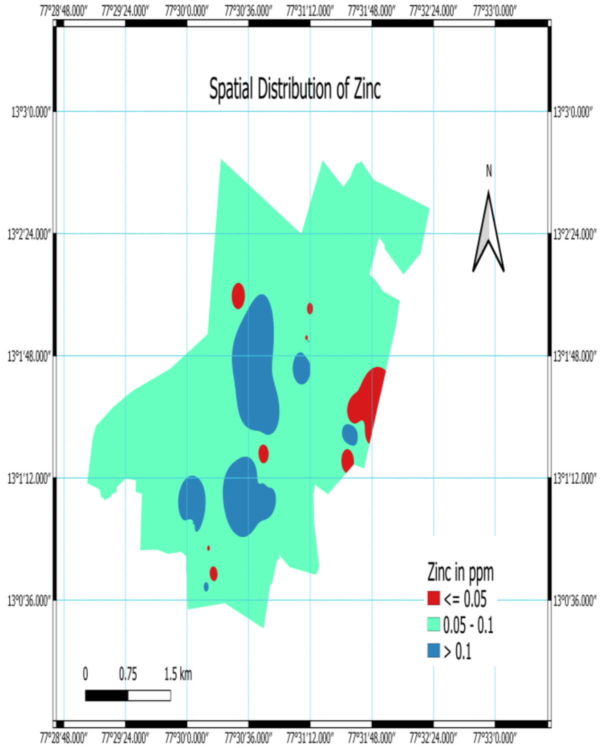

Fig 12

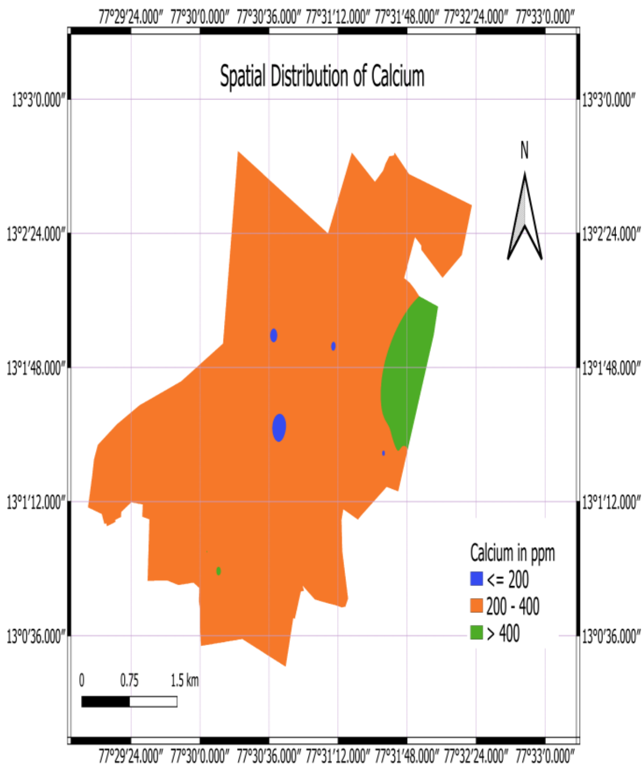

Fig 13

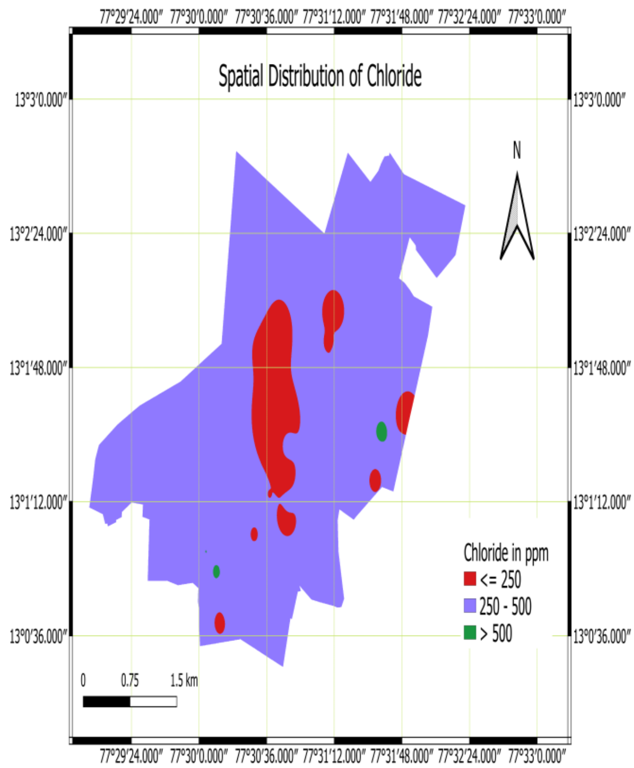

Fig 14

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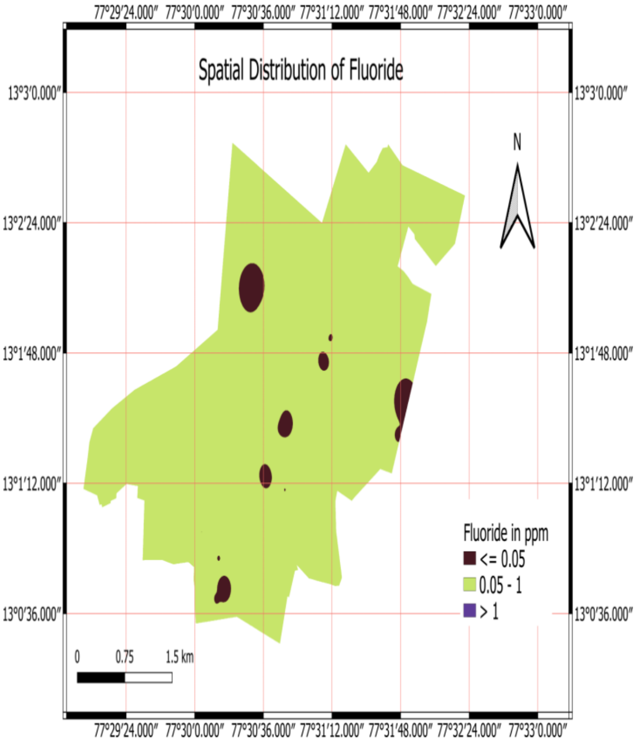

Fig 15

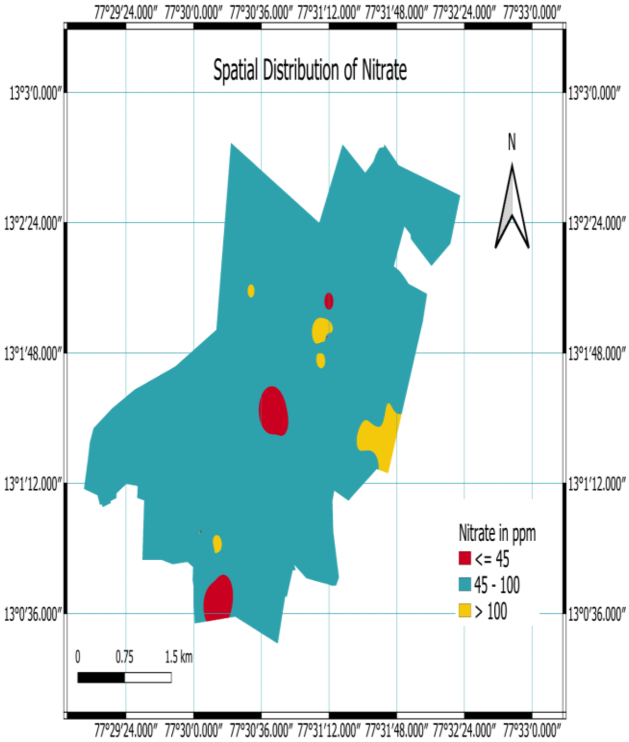

Fig 16

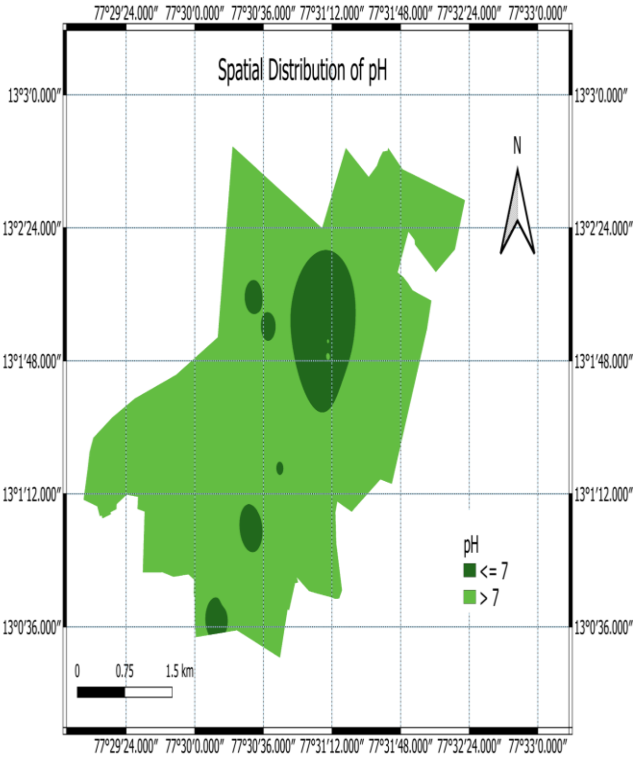

Fig 17

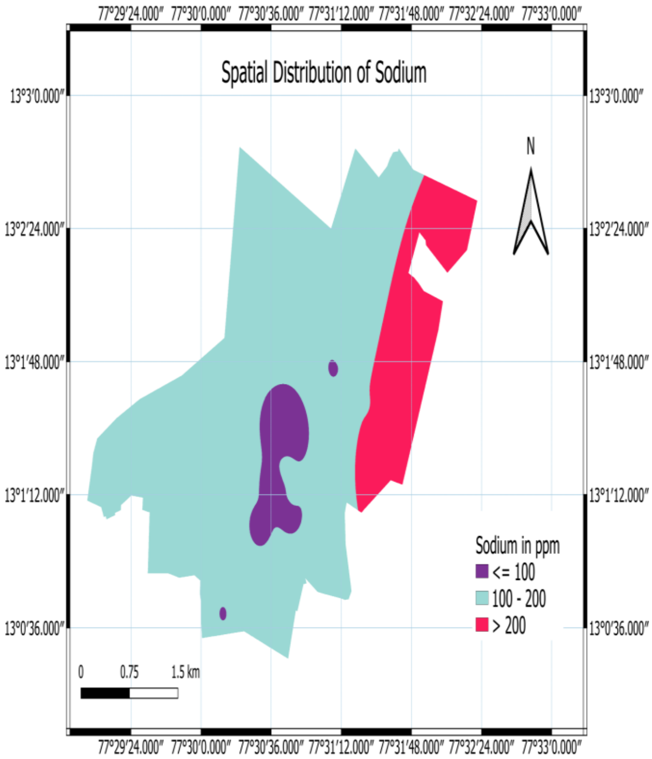

Fig 18

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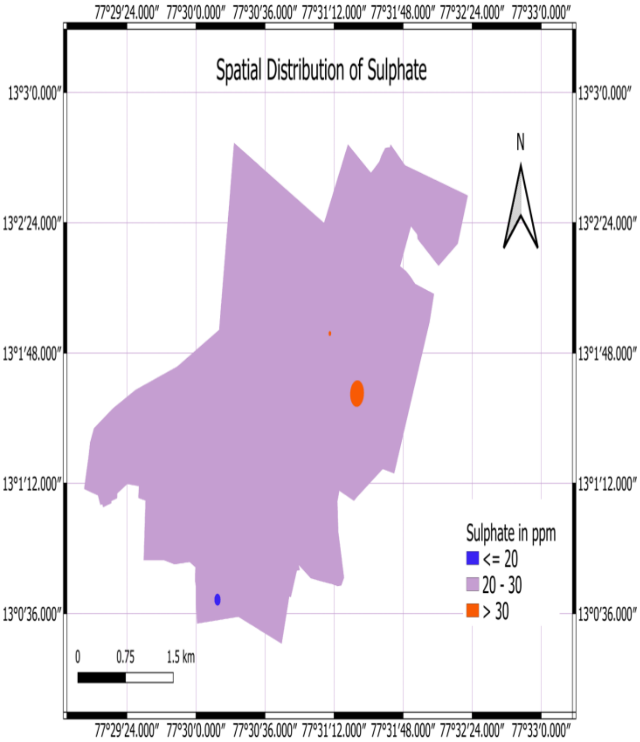

Fig 19

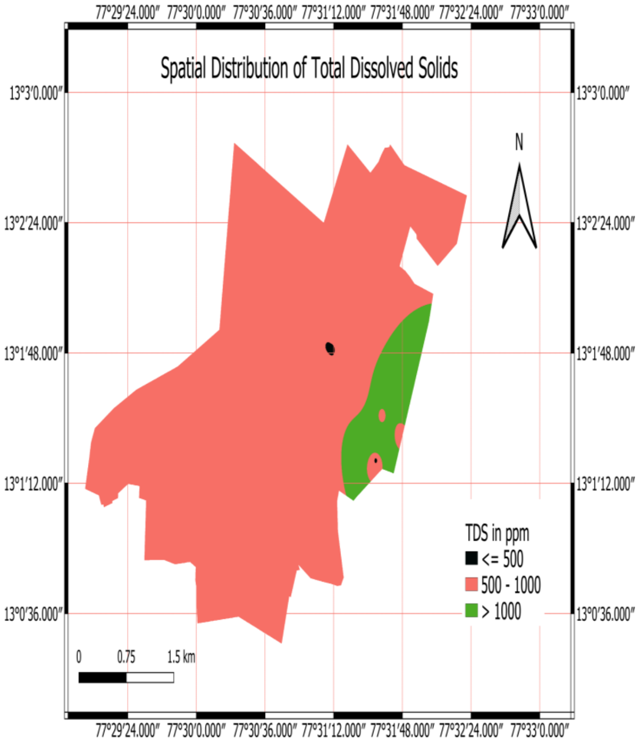

Fig 20

- From the analysis we found that the pH values are within the permissible limits except for 6^{th} sampling station where pH is 5.09 indicates acidic (Fig 17). The values of electrical conductivity found to be between 362–6350 µs/cm.
- The permissible limits for total dissolved solids is 500-2000 mg/l, the study reveals that the values of TDS are within the permissible limit, except for 27^{th} sampling station which recorded a value of 3960 mg/l exceeding the limit. 50% of (15 samples out of 30) samples are exceeding the permissible limit of Total Hardness i.e. 600 mg/l **(**Fig 6) and 24% of (7 samples out of 30) samples are exceeding the permissible limit of nitrate i.e.100 mg/l (Fig 16).
- Chloride content in the study area ranges from 73.87-708.77 mg/l (Fig 14), fluoride content ranges between 0.018-0.23 mg/l (Fig 15) and that of sulfates is between 17.94-32.59 mg/l (Fig 19) which are well within the permissible limit.
- Calcium concentration is high at all 30 sampling stations varied between 124-1321 mg/l (Fig 13).
- Copper is detected in only 10 samples out of 30, in which 2 samples are exceeding permissible limit i.e. 0.05 mg/l (Fig 8). Higher concentrations can cause vomiting, diarrhea even damages the liver.
- Out of 30 samples nickel detected in 27 samples, where nickel is high in 16 samples exceeding 0.02 mg/l and except sampling station 26 zinc is detected at all locations which are well within the permissible limit of 5 mg/l (Fig 10).
- Cadmium and chromium is detected in all samples out of which 34% of (10 samples out of 30) samples are exceeding the permissible limit of cadmium i.e. 0.01 mg/l (Fig 7) and 87% (26 samples out of 30) are exceeding the permissible limit of chromium i.e. 0.05 mg/l (Fig 9). Cadmium salts causes cramps, vomiting, and arterial hypertension excess chromium makes water toxic and causes ulcers, dermatitis.
- Mercury and arsenic are detected at all 30 locations which are exceeding their permissible limits for mercury 0.001 mg/l and for arsenic 0.01 mg/l (Fig 11). Higher concentrations of mercury can cause neurological and renal disturbances and arsenic causes skin cancer.
- The graphs shows that the highest value of copper is recorded at 16th location (Fig 3) chromium at 5th location, zinc at 8th location (Fig 4) and mercury at 29th location (Fig 5) also reveals that the chromium, cadmium and mercury are dominant in study area.

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V. CONCLUSION

From the results obtained we can conclude that the groundwater quality in the study area is very poor due to contamination from industries and landfill or dumping of Hazardous wastes can lead to groundwater contamination
And periodical monitoring of groundwater becomes necessary to control and avoid further contamination. Analysis showed that the use of GIS tool is effective in representing the distribution of different parameters and enables easy reading by reducing time and helps in making quick decisions. Maps shows that heavy metals like Chromium, cadmium, arsenic and mercury are dominant in the groundwater of study area. Study shows that it becomes crucial to check effluent characteristics regularly, setting up of effluent treatment plant and ensuring their proper operation also preventing the contamination of groundwater through leakage from pipes carrying sewage or any toxic chemicals by replacing damaged pipelines, soil pollution should be reduced and prevented especially by providing protective landfill liners and leachate collection systems at landfill sites and dumping stations as soil acts a primary mode through which groundwater is polluted. The present study reveals that groundwater of the study area needs particular degree of treatment and protected to reduce future contamination.

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