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INVESTIGATION ON GROUNDWATER, SOIL AND VEGETATION QUALITY WITH SPECIAL REFERENCE TO HEAVY METALS AROUND VRISHABHAVATHI VALLEY, BANGALORE

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ABSTRACT

In this study an investigation on groundwater, soil and vegetation quality with special reference to heavy metal around Vrishabhavathi valley, Bangalore was done. Total 35 number of groundwater samples are taken from the Vrishabhavathi valley at Kengeri, Bangalore, and studied for physicochemical parameters, heavy metals like copper, chromium, nickel. 8 numbers of soil samples are taken analyzed for heavy metals (Cu, Cr, Ni) by mehlich-1 extraction method, vegetation samples (Fenugreek leafs, Amaranthus leafs, Mint leafs, Spinach leafs, Radish) which are grown in the Vrishabhavathi wastewater are analyzed for heavy metals by using AAS (Atomic Absorption Spectrophotometer) at Environmental Engineering Laboratory, BMSCE, Bangalore. Concentrations obtained for each of the samples were compared with the BIS is: 10500, 2012 for drinking water quality standard limits. All the concentrations of above analyzed samples like physicochemical parameters i.e. TDS, Conductivity, pH, Alkalinity, Calcium, Magnesium, Chloride, Nitrate, Hardness, and heavy metals i.e. Copper, Nickel, Chromium, are represented spatially by using the specialized software called GIS (Geographic Information System) which represents the concentrations of each of the parameters spatially with respect to their sampling locations.

INTRODUCTION

Heavy metals are in their combined form with varied metal groups and differentiable in physical and chemical, biological properties. Heavy metals are of high density or high relative atomic weight which gets contaminated with the ground water and soil by both man made and anthropogenic activities [1]. Heavy metals are toxic in nature, present in various compound forms also and since heavy metals are biologically non degradable they may cause a severe damages to the human life who are exposed to it, when heavy metals leaches to the ground water through the soil which contaminates both soil and ground water [2]. Once the soil gets contaminated it may starts changing the natural soil potentials like pH, temperature, soil stability, and other general soil characteristics. The heavy metals being non-biodegradable they accumulates in the deeper layer of the soil and will be there for a prolonged time until the soil mass gets disturbed physically or it undergone a change in its structure [3].

Even these heavy metals which were present in the soil may leads to the bioaccumulation in the soil and the the vegetation grown in that soil. Here there are two chances of vegetation grown in that area gets contaminated like the heavy metals may leaches or get absorbed by the plant by the soil contaminated or else it may get absorbed by the wastewater which was fed to the crop land for the purpose of irrigation [8]. These bio accumulated heavy metal concentration in the vegetables, crops, will leads to the serious issues of the health in human populations. Who are going to be exposed or consume the contaminated vegetables or the food products. Which further leads to the health problems in the humans and causes birth defects, genetical modifications, neurological problems, heart problems, cancer, and some other permanent disorders [6].

Study Area

The Bangalore was located at a latitude 12.58'N and longitude of 77.35'E and an altitude of 921m, in the southern part of the India. Is one of the fastest growing city in the state of Karnataka now a days, and Vrishabhavathi is an oldest drain of the Bangalore which drains around 30% of the Bangalore's daily sewage, it carries a sewage from the major industrial areas of Bangalore which are Rajajinagara, Rajarajeswari Nagara and Peenya, Kengeri, etc. And flows further through the Mysore road reaches the Byramangala tank near the Ramanagara district. This

valley is polluted due to the discharge of the major industrial effluent discharges from the industries found along the banks, also from the untreated effluent discharge to the valley from the municipal treatment plants, etc., due to these human activities the Vrishabhavthi valley was severely contaminated with heavy metals and trace toxicants, pesticides [12]. Contaminants which include both organic and inorganic compounds. And which further leads to the contamination of the surrounding surface as well as ground water bodies, and the soil which was exposed to the contaminated wastewater. Map of the Study Area Vrishabhavathi Valley, Kengeri, Bangalore, was shown in Figure.1.

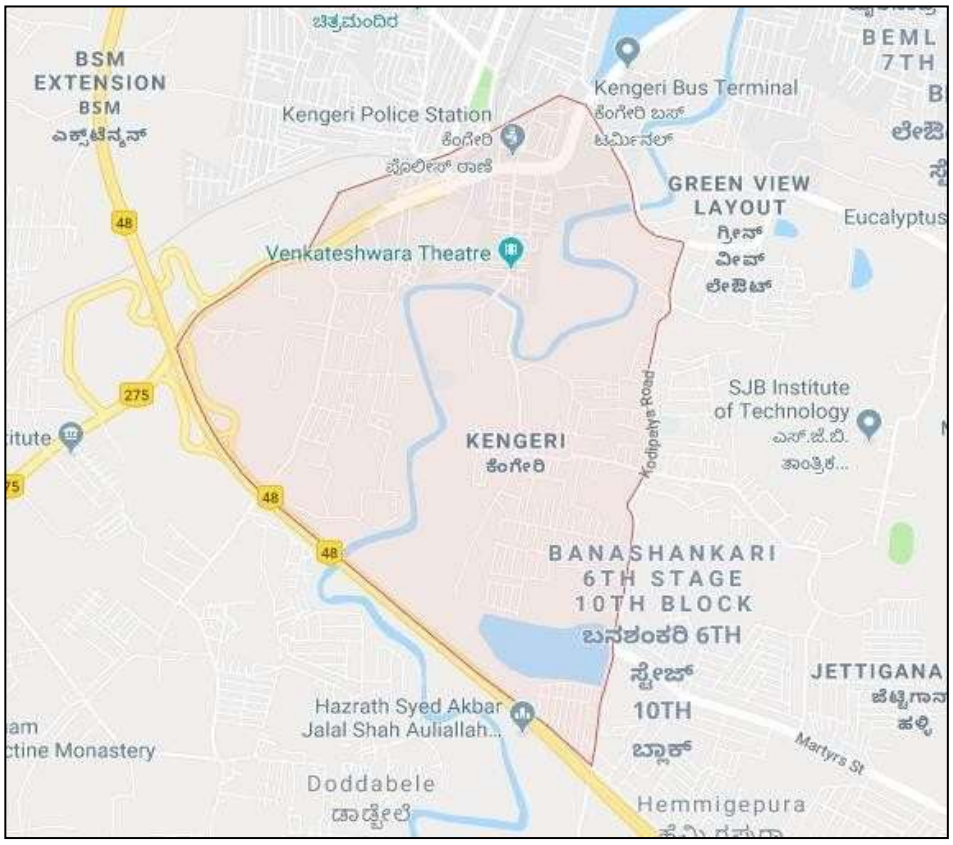


Figure.1: Map of the Study Area

MATERIALS AND METHODS

35 number of groundwater samples were collected from the Vrishabhavathi valley, taken from the deep wells in the plastic containers of capacity 1 liter. In the month of March second week 2018, 25 numbers of ground water samples were collected from the residential areas in the study area as a phase-1. 4 numbers of soil samples were taken in the same month. In phase-2 in the second week of April 2018, about 10 ground water samples were taken from the same study area along the Vrishabhavathi valley at an average distance of 200m each side perpendicularly to the valley. Also 4 soil samples were taken in the area in this month. All the soil samples were of disturbed type collected in the polythene bag. Some of the leafy vegetables like Amaranthus, Fenugreek, Mint, Spinach, and Radish were taken for analysis of heavy metals. Groundwater samples were analyzed for physico-chemical parameters like TDS, Hardness, Alkalinity, pH, Conductivity, Nitrate, Calcium, Magnesium, Chloride, using standard laboratory methods. The soil samples were analyzed by using mehlich-1 extraction procedure. In this method mehlich-1 extraction (0.05N HCL and 0.025N H2SO4) was prepared first then, the soil samples were oven dried for 24h at a temperature of 100-105C. Cooled to a room temperature grinded using mortar and pestle to the finer form, sieved through 1mm sieve. 5 gm of sieved sample was taken in a conical flask with 20 ml of mehlich-1 extraction solution and kept on a mechanical shaker for 10 minutes at 250 RPM. Then that is filtered through a whatmen no.42 paper, the filtrate is diluted to the 50 ml using the same mehlich-1 extraction solution.

And analyzed for the heavy metal Concentration using AAS at Environmental Engineering Laboratory of B.M.S.C.E, Bangalore. Vegetable samples were air dried for 2 days, and oven dried at 70c to 80c till all the moisture content removed grinded using mortar and pestle, sieved through 1mm nylon mesh 1gm of sieved sample was digested in an 1:1 nitric acid solution and filtered through a whatmen filter paper no.42 and diluted to 100ml using distilled water analyzed for the heavy metal concentration by using AAS. All the concentrations obtained are represented spatially by using the specialized software called GIS (Geographic Information System) which represents the concentrations of each of the parameters spatially with respect to their sampling locations. Spatial Representation of Groundwater Sampling Locations in the Study Area was shown in the Figure.2. Spatial Representation of soil Sampling Locations in the Study Area is shown in Figure.3.

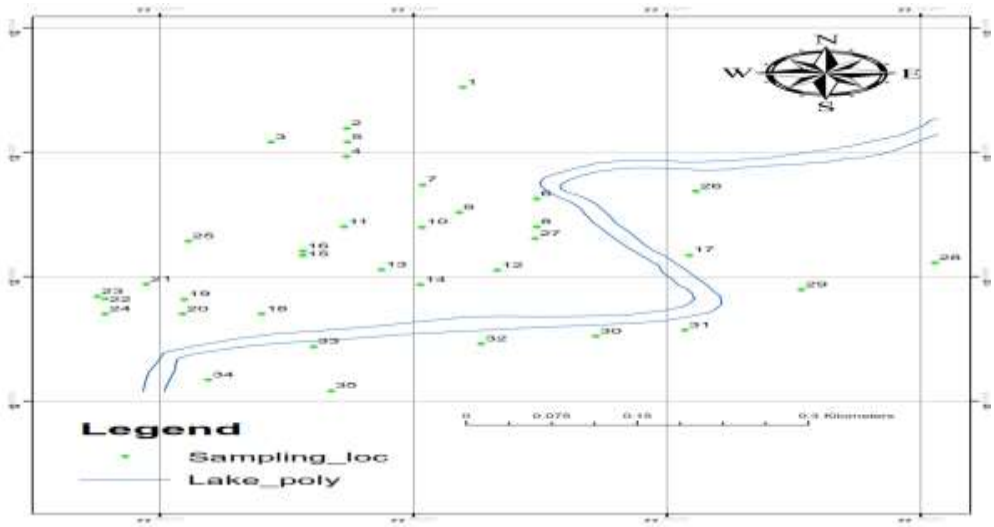


Figure.2: Spatial Representation of Groundwater Sampling Locations in the Study Area

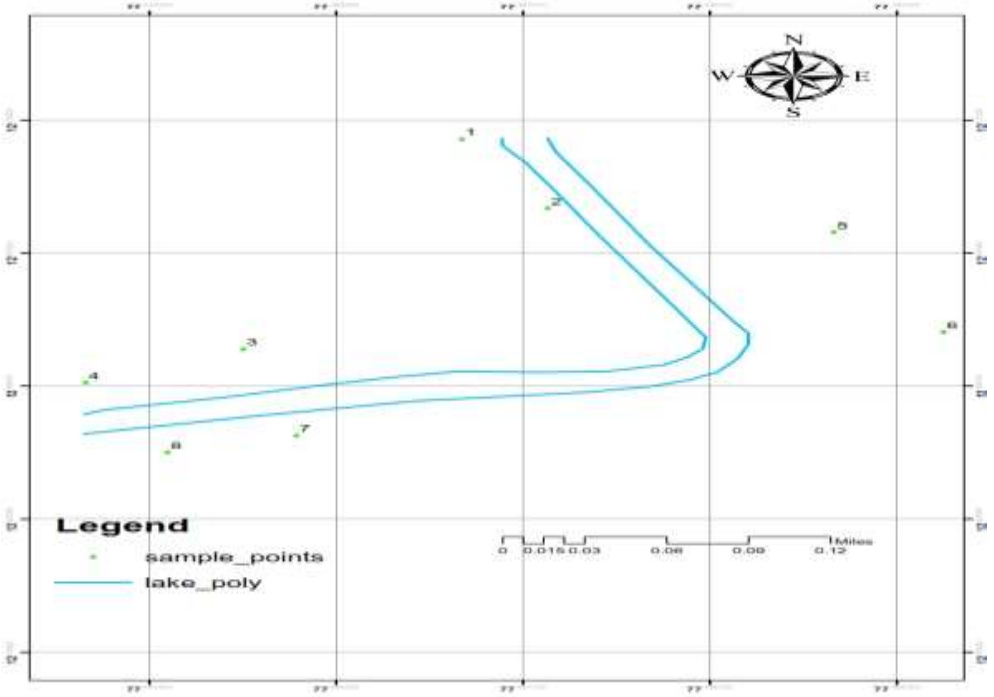


Figure.3: Spatial Representation of soil Sampling Locations in the Study Area

RESULTS AND DISCUSSION

For Physicochemical Parameters of Groundwater.

The pH in the groundwater obtained from the samples collected were well within the limits of BIS standards IS: 10500, 2012. And most of the pH values of the groundwater in the study area were in the limit i.e. 6.5 to 8.5. Out of all the 35 number of samples the highest pH was obtained at the sample number-11 i.e. 8.24. The lowest pH value was found in the sample number 8 i.e. 6.75. The TDS obtained in all the water samples were well within the limits the maximum value out of all the readings were observed in the sample number-15, and the value is 1307 (mg/l), and the minimum value obtained in the sample No.2, i.e. 624 (mg/l).The conductivity in the area of study has got a maximum value of 3 mS, and a minimum value of 0.66 mS, in sample No.21 and No.15 respectively. The hardness observed in the area is maximum at the sample No.10, i.e. 315 (mg/l), the minimum value was found out to be 261 at the sample No.20 respectively and both of them were exceeding the standard limits as per the BIS limits. Calcium in the area found out to be maximum in sample No.11, that is 78 (mg/l), and minimum in sample No.17, the value is 64.32 (mg/l), the rest of the readings were well within the limits. Magnesium is maximum in sample No.26, the value is 40(mg/l), and minimum was found in sample No.9, that is 27.18 (mg/l), and the maximum value obtained here was exceeding the limit which was acceptable. The nitrate in the area was maximum in sample No.10,the value is 28 (mg/l), and minimum in sample No.33, is 13 (mg/l), and all the values obtained in the area of the study for the nitrate were well within the limits which is acceptable. Chloride was found maximum in sample No.1 and No-34, that is 245.16 (mg/l), and minimum was 109.34 (mg/l), in sample No.19. For alkalinity the values were 30 (mg/l), and 210 (mg/l) obtained as minimum and maximum in sampling No.17 and No.32, respectively. The concentrations of Physicochemical Characteristics of Groundwater in Study Area were shown in the Table.1.

For Heavy Metals Concentration in groundwater.

So among the obtained results the maximum and minimum values of the each of the heavy metals were observed and the values of each of them are discussed below for chromium the maximum value observed was 0.0405 (mg/l), in sample No.21 and minimum value was 0.0023 (mg/l) in sample No.34, and all the heavy metals were within the acceptable limits of the standard. Copper values are 0.09 (mg/l), and 0.002 (mg/l), was observed in sample numbers 17 and 33. All of them were below the acceptable limits of the standard limits. Nickel values were also found within the limits and the values were 0.008 (mg/l), and 0.0014 (mg/l) found at the sample numbers 26 and for the minimum value the concentration was found low at two samples that is at no.3 and no.30. The concentrations of heavy metal in Groundwater shown in Table.2.

For Heavy Metal concentration in Soil.

In the study area it was observed that the heavy metal concentrations are going to be decreased from surface to the deeper sections in the ground at a depth of 20 cm, 40cm, and at 60 cm, depths from the surface. These decreased concentrations were observed because of the various climatological changes in the ground reality in the study area also due to the weathering actions due to the various man mad activities like ploughing and crop rotations, etc. Will causes the change in the concentrations in the descending order, depth wise. These elevated concentrations of the heavy metals were due to the direct feeding of the Vrishabhavathi sewage water on to the agricultural lands without any pretreatment of the sewage. The maximum values were 18.4 mg/kg, for Copper at the sampling location number-5, and minimum at location number-2 that is 3.3 mg/kg the Spatial Representation of Copper in Soil was shown in the figure.4. For Chromium the maximum and minimum values were 9.4 mg/kg, and 2.3 mg/kg, at the sampling locations number- 7 and 2, respectively. The values of nickel obtained were found maximum at the sampling locations no.5, that is 12 mg/kg, and minimum was found at the sampling location no.7, that is 1.2 mg/kg. Spatial Representation of Nickel in Soil shown in figure.5. The concentrations of heavy metals in soil were shown in table.3. The Migration of Heavy Metals in Soil at location No.2 and No.7 were shown in the Figure.6 and Figure.7.

Heavy Metal Concentrations in Vegetations of the Study Area.

The analysis was done for three heavy metals Copper, Chromium, and Nickel the greater concentrations of the Copper was found in the vegetable Fenugreek that is 310 microgram/ gram, minimum in the vegetable Mint that is 155 microgram/ gram, elevated concentrations of the Chromium was found in the vegetable Radish that is 235 microgram/ gram, minimum value was found out to be 140 microgram/ gram, in the leafy vegetable Mint. One

more heavy metal, which is Nickel, was found in an elevated concentration in the vegetable Radish the value is 410 microgram/ gram and the minimum value of the Nickel was found in the vegetable Mint that is 117.5 microgram/ gram. Heavy metals concentrations in vegetation were shown in Table.4. From the above obtained results it was found that the concentrations of all the three heavy metals were minimum observed in the leafy vegetable Mint. This was may be due to the less absorptive capacity of the mint shoots for the heavy metals through the soil or the irrigated water in the land. It is found that the heavy metal absorptive capacity was found to be more in the vegetable Radish as compared to other four of the vegetables taken in this study. The variation of heavy metal concentrations in vegetation shown in Figure.8

Table.1: Concentrations of Physicochemical Characteristics of Groundwater in Study Area

Sample.No	Latitude	Longitude	pH	TDS (mg/L)	Conductivity (mS)	H (mg/L)	Ca (mg/L)	Mg (mg/L)	Nitrate (mg/L)	Cl (mg/L)	Alkalinity (mg/L)
GW1	12°54'49"N	77°29'12"E	8.22	1234	2.35	310	74.16	30.15	24	245.16	320
GW2	12°54'46"N	77°29'9"E	8.23	1237	2.34	304	66.25	28.32	0	194.32	290
GW3	12°54'45"N	77°29'7"E	7.02	972	2.32	280	70.41	29.68	20	215.46	300
GW4	12°54'44"N	77°29'9"E	7.01	940	2.32	272	68.82	28.32	22	196.87	290
GW5	12°54'45"N	77°29'9"E	6.93	982	2.31	300	71.14	31.06	26	228.1	308
GW6	12°54'41"N	77°29'14"E	7.09	835	2.08	303	70.32	30.08	14	175.08	298
GW7	12°54'42"N	77°29'11"E	7.29	854	2.13	280	72.67	32.17	18	235.67	300
GW8	12°54'39"N	77°29'14"E	6.75	932	2.31	275	74.81	39.16	21	240.32	304
GW9	12°54'40"N	77°29'12"E	6.96	765	1.88	290	69.39	27.18	26	244.59	300
GW10	12°54'39"N	77°29'11"E	7.58	744	1.88	315	76.39	36.04	28	194.36	320
GW11	12°54'39"N	77°29'9"E	8.24	906	2.23	300	78.58	38.12	22	208.14	340
GW12	12°54'36"N	77°29'13"E	7.54	624	1.59	301	74.62	32.11	24	199.36	320
GW13	12°54'35"N	77°29'11"E	7.15	1307	2.67	274	70.74	30.04	20	208.14	300
GW14	12°54'36"N	77°29'10"E	7.23	768	1.96	287	74.55	32.16	24	199.12	310
GW15	12°54'37"N	77°29'8"E	7.90	252	0.66	290	72.32	30.12	20	169.45	318
GW16	12°54'36"N	77°29'9"E	7.20	955	2.35	294	78.18	34.01	24	178.67	320
GW17	12°54'37"N	77°29'18"E	7.23	725	1.82	297	64.32	28.19	26	194.32	210
GW18	12°54'33"N	77°29'7"E	7.10	1284	2.46	287	74.16	32.16	0	204.56	310
GW19	12°54'34"N	77°29'5"E	7.24	1685	2.7	274	78.32	34.18	21	109.34	318
GW20	12°54'33"N	77°29'5"E	7.03	791	2.06	261	70.81	30.12	20	198.74	308
GW21	12°54'35"N	77°29'4"E	7.09	1210	3.00	301	76.36	32.08	18	202.45	320
GW22	12°54'34"N	77°29'3"E	7.12	1120	2.73	295	74.18	30.04	24	214.06	310
GW23	12°54'34"N	77°29'3"E	7.30	883	2.17	286	72.36	31.12	26	228.34	304
GW24	12°54'33"N	77°29'3"E	7.34	875	2.16	267	71.43	31.03	22	195.14	297
GW25	12°54'38"N	77°29'5"E	7.30	820	1.87	272	68.55	29.05	20	184.75	292
GW26	12°54'41.49"N	77°29'18.12"E	7.20	1020	2.1	274	75	40	21	240	304
GW27	12°54'38.17"N	77°2920.26"E	7.10	980	2.7	277	74	30	14	175	298
GW28	12°54'36.45"N	77°29'24.27"E	6.97	870	2.3	284	71	31	26	228	308
GW29	12°54'34.64"N	77°29'20.83"E	7.60	980	2.4	290	70	30	14	175	298
GW30	12°54'31.44"N	77°29'15.54"E	7.40	940	1.97	300	78	38.12	22	196.87	290
GW31	12°54'31.86"N	77°29'17.78"E	7.46	990	2.12	304	67	26.18	17	233.21	300
GW32	12°54'31"N	77°29'12.59"E	6.98	1000	2.11	301	78.5	38.12	22	197.31	330
GW33	12°54'30.82"N	77°29'8.33"E	8.10	1201	1.8	307	73.4	30.15	13	174.31	296
GW34	12°54'28.54"N	77°29'5.77"E	7.58	1043	1.88	298	77.42	37.21	24	245.16	310
GW35	12°54'27.85"N	77°29'8.92"E	7.09	994	1.67	281	73.67	33.41	21	240.32	317

Table.2: Concentrations of heavy metals in Groundwater

Sample.No	Latitude	Longitude	Cr (mg/l)	Cu (mg/l)	Ni (mg/l)
GW1	12°54'49"N	77°29'12"E	0.0112	0.04	0.007
GW2	12°54'46"N	77°29'9"E	0	0.05	0.0021
GW3	12°54'45"N	77°29'7"E	0.0014	0.02	0.0014
GW4	12°54'44"N	77°29'9"E	0	0.06	0
GW5	12°54'45"N	77°29'9"E	0	0.06	0
GW6	12°54'41"N	77°29'14"E	0.0028	0.04	0
GW7	12°54'42"N	77°29'11"E	0.0171	0.03	0
GW8	12°54'39"N	77°29'14"E	0.0063	0.06	0
GW9	12°54'40"N	77°29'12"E	0	0.06	0
GW10	12°54'39"N	77°29'11"E	0	0.01	0
GW11	12°54'39"N	77°29'9"E	0.0041	0	0
GW12	12°54'36"N	77°29'13"E	0	0	0
GW13	12°54'35"N	77°29'11"E	0	0	0
GW14	12°54'36"N	77°29'10"E	0	0.02	0
GW15	12°54'37"N	77°29'8"E	0	0.01	0
GW16	12°54'36"N	77°29'9"E	0.0081	0	0
GW17	12°54'37"N	77°29'18"E	0.0313	0.09	0
GW18	12°54'33"N	77°29'7"E	0.0029	0.03	0
GW19	12°54'34"N	77°29'5"E	0.0205	0	0
GW20	12°54'33"N	77°29'5"E	0	0.03	0
GW21	12°54'35"N	77°29'4"E	0.0405	0	0
GW22	12°54'34"N	77°29'3"E	0.0053	0.03	0
GW23	12°54'34"N	77°29'3"E	0	0.02	0
GW24	12°54'33"N	77°29'3"E	0.0148	0.01	0
GW25	12°54'38"N	77°29'5"E	0.0025	0.02	0
GW26	12°54'41.49"N	77°29'18.12"E	0.0123	0.05	0.008
GW27	12°54'38.17"N	77°2920.26"E	0.0012	0.041	0
GW28	12°54'36.45"N	77°29'24.27"E	0	0.023	0.0017
GW29	12°54'34.64"N	77°29'20.83"E	0.061	0.09	0
GW30	12°54'31.44"N	77°29'15.54"E	0.017	0.04	0.0014
GW31	12°54'31.86"N	77°29'17.78"E	0	0.03	0.0021
GW32	12°54'31"N	77°29'12.59"E	0.0041	0.01	0
GW33	12°54'30.82"N	77°29'8.33"E	0	0.002	0
GW34	12°54'28.54"N	77°29'5.77"E	0.0023	0.06	0.006
GW35	12°54'27.85"N	77°29'8.92"E	0.0027	0.03	0.004

Table.3: Concentrations of heavy metals in soil.

Samples	Latitude	Longitude	Heavy Metals (mg/kg)	0 (cm)	20 (cm)	40 (cm)	60 (cm)
S1	12°54'41.92"N	77°29'13.35"E	Copper	14.6	14.3	10.4	8.6
			Nickle	1.7	1.8	2.1	2.4
			Chromium	5.2	4.8	2.1	0.9
S2	12°54'39.25"N	77°29'15"E	Copper	3.3	3.4	2.7	10.9
			Nickle	0	1	2.1	0.8
			Chromium	2.3	2	9.5	0.9
S3	12°54'33.85"N	77°29'9.18"E	Copper	16.8	10.2	9.6	10.4
			Nickle	11.3	12.1	6.1	5.7
			Chromium	6.4	4.1	3.8	2
S4	12°54'32.57"N	77°29'6.15"E	Copper	4.9	5.1	3.4	2.9
			Nickle	9.6	7.4	6.1	2.3
			Chromium	4.2	3.3	2.8	1.9
S5	12°54'38.30"N	77°29'20.52"E	Copper	18.4	12.3	9.7	2.4
			Nickle	12	11.9	9.7	7.6
			Chromium	7.3	6.4	5.7	3.2
S6	12°54'34.51"N	77°29'22.62"E	Copper	7.6	4.2	3.1	0.9
			Nickle	9.1	8.7	6.7	4.8
			Chromium	1.9	0	2.1	1.6
S7	12°54'30.53"N	77°29'10.21"E	Copper	4.8	6.1	3.7	10.4
			Nickle	1.2	1.1	1	8.7
			Chromium	9.4	8.7	6.4	4.3
S8	12°54'29.90"N	77°29'7.75"E	Copper	8	4.2	3.1	0.9
			Nickle	6	5.7	4.1	1.9
			Chromium	4.7	3.7	2.8	1.2

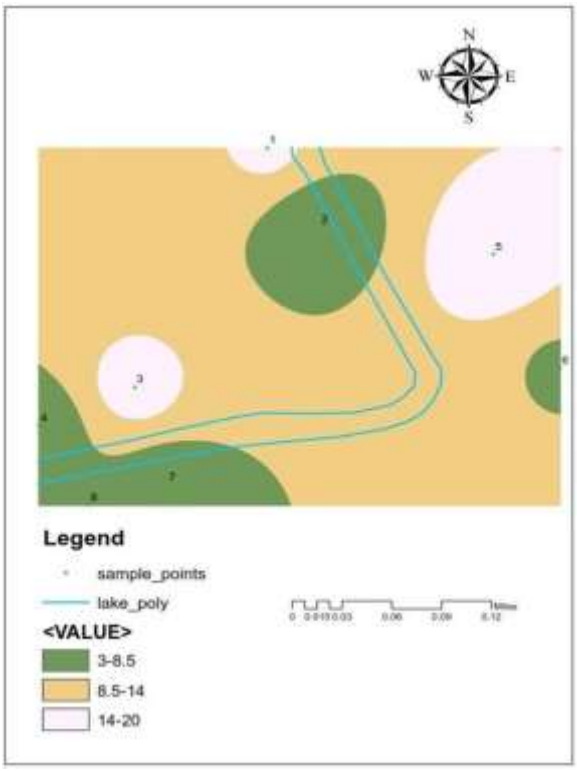


Figure.4: Spatial Representation of Copper in Soil

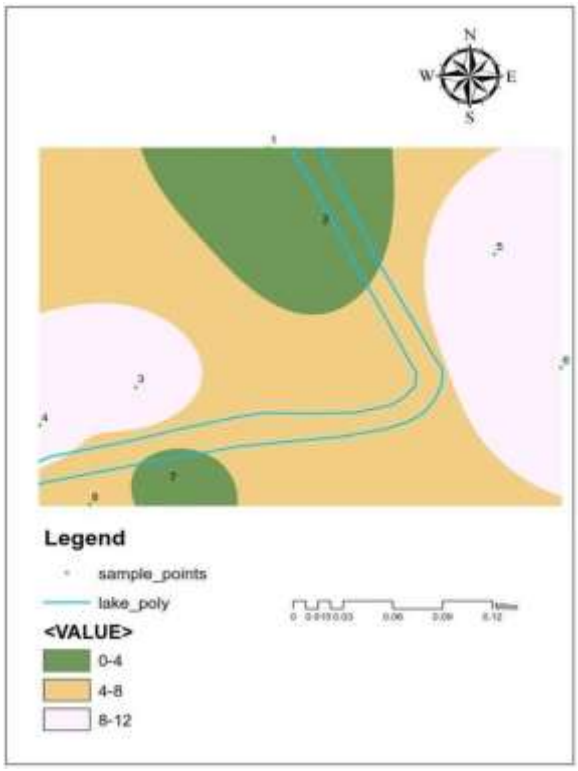


Figure.5: Spatial Representation of Nickel in Soil

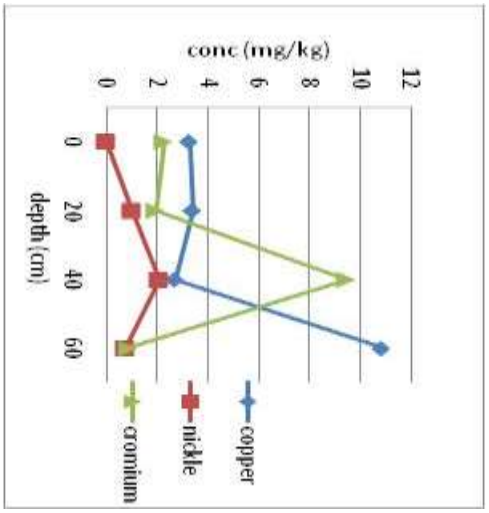


Fig.6: Migration of Heavy Metals in Soil at location No.2

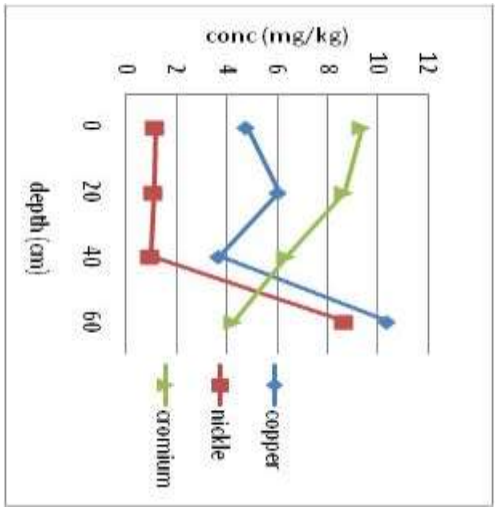
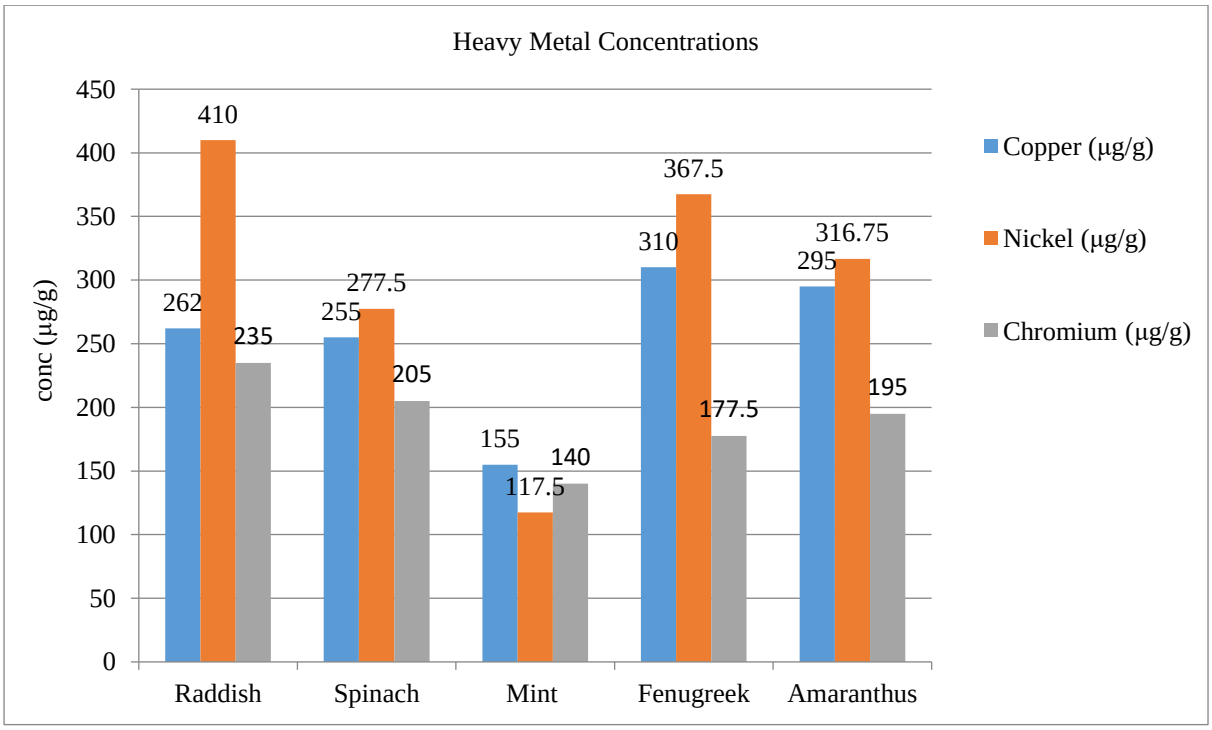


Fig.7: Migration of Heavy Metals in Soil at location No.7

Table.4: Concentrations of Heavy Metals in Vegetation

Samples	Copper (µg/g)	Nickel (µg/g)	Chromium (µg/g)
Raddish	262	410	235
Spinach	255	277.5	205
Mint	155	117.5	140
Fenugreek	310	367.5	177.5
Amaranthus	295	316.75	195



Figre.8: Variation of Heavy Metal Concentrations in Vegetation

CONCLUSIONS

The concentrations of TDS found maximum 1700 (mg/l), in sample No.19 was more than the acceptable limit. Hardness is maximum at sample No.11 that is 320 (mg/l), Calcium samples found more than the acceptable limits in 6 samples rest of them are within the limits. Magnesium concentration was more than the acceptable limits in 16 samples and concentration of Alkalinity are more than the limits in all the ground water samples in the study area. Concentration of Chromium in the sample No.29 is more than the limit and in sample No.19, No.31, the concentration of Copper was more than the standard limits. The concentrations of Copper in soil was more at the depth of 60cm in sample No.2, for Nickel concentration was more at depth of 40cm, and 60cm, in the sample No.7. Heavy metals like Nickel were more concentrated in the vegetable Radish that is 410 micro gram/ gram.

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REFERENCES

1. Rani Et.Al "Water Quality Analysis: A Case Study In Byramangala Lake Water And Surrounding Ground Water" International Journal Of Scientific And Engineering Research Vol.5 (Iss.4: Rasm), April, 2017
2. Jayadev, E.T Puttaih Heavy Metal Contamination In Soil Under The Application Of Polluted Sewage Water Across Vrishabhavathi River, International Journal Of Engineering Research And Applications (Ijera) Vol. 2, Issue 6, November- December 2012
3. Jayadev Et.Al Assessment Of Heavy Metals Uptake In Leafy Vegetables Grown On Long Term Wastewater Irrigated Soil Across Vrishabhavathi Valley, Bangalore, Journal Of Environmental Science, Toxicology And Food Technology Volume 7, Issue 6 (Nov. - Dec. 2013),
4. Tong-Bin Chen, Yuan-Ming Zheng, Mei Lei, Ze-Chun Huang, Hong-Tao Wu, Huang Chen,Ke-Ke Fan, Ke Yu, Xiao Wu, Qin-Zheng Tian "Assessment Of Heavy Metal Pollution In Surfacesoils Of Urban Park In Beijing, China". Chemosphere, 60, 542-551, (2005)
5. S.Srinivasa Gowda, P.K Govil And M.Ramakrishna Reddy "Assessment Of Heavy Metals Contamination In Soils At Jajmau (Kanpur) And Unnao Industrial Area Of The Ganga-Plane Uttar Pradesh, India". Journal Of Hazardous Materials, 174, 113-121 (2010)
6. Shrivastava And S.P.Mishra "Studies Of Various Heavy Metal In Surface And Ground Water Of Birsinghpur Town And Its Surrounding Rural Area District Satna (MP)" Current World Environmental – Vol.6 (2); 271-274, (2011)
7. Rakesh Sharma M. S And Raju N.S "Correlation Of Heavy Metal Contamination With Soil Prosperities Of Industrial Areas Of Mysore, Karnataka, India By Cluster Analysis". International Research Journal Of Environment Sciences Vol.2(10); 22-27, Oct (2013)
8. A Ramesh, B.S Nagendra Prakash, P.V.Sivapullaiaih, A.S Sadhashivaiah "Assessment Of Groundwater Quality In Designated Peenya Industrial Area And Estate, Bangalore, India – A Case Study" International Journal Of Environmental Protection – Vol.2 (6); 21-25, (2012)
9. Ata.Shakeri, Farid Moore Soroush Modabbere "Heavy Metal Contamination And Distribution In The Shiraz Industrial Complex Zone Soil, South Shiraz, Iran". World Applied Science Journal, 6(3), 413-425, (2009)
10. A.K Krishna & P.K Govil "Soil Contamination Due To Heavy Metals From An Industrial Area Of Surat, Gujarat, Western India". Environ Monit Assess, 124, 263-275, (2007)
11. Muhammud Et.Al A Study On The Accumulation Of Heavy Metal In The Agricultural Soil In Various Parts Of Peri-Urban Parts Of The Central Punjab, International Journal Of Environmental Protection – Vol.1 (8); 23-28, (2013)
12. Jiban Et.Al Investigation For Heavy Metals In The Ground Water At Challaghatta, Koramangala, Hebbal Valleys, Bangalore. Journal Of Environmental Science, Toxicology And Food Technology Volume 7, Issue 6 (Nov. - Dec. 2013).