ISSN: 0971-1260
Vol-22-Issue-17-September-2019

Elemental Analysis For Presence of Heavy Metals in Soil Samples, Gandhinagar Gujarat: A Monitoring Study

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ABSTRACT
Soil serves as the common ground for existence of organic as well as inorganic components and thus supports various life forms, ranging from microbial population to evident flora and fauna. The study of soil (pedology) which studies soil in its natural environment is important for soil profiling. Soil profile detailing iscrucial and important for estimating the probable use of soil or understanding the intended use of soil. Scientific detailing of the soil is not only useful for farming purposes but also for land use planners who require data to interpret whether the soil is fit for human dwelling and habitation or not, and scientists.

Approximately 5% of heavy metals and 95% of iron(weight by weight) comprise the Earth's crust composition.In addition to the natural occurrence of the heavy metals, the surge in heavy metal concentration in the earth may be accredited to the human activities such as mining, industrial effluent discharge, untreated waste discharge, leaded petrol and paint, untreated sewage, use of pesticides and fertilizers in farms and petrochemical wastes.Soil is considered to be the ultimate receptor of the pollutants resulting from discharge of various effluents in the environment as a result of different aforesaid anthropogenic activities. Unlike organic wastes, heavy metals do not undergo degradation by chemical or microbial action and hence get accumulated in particular soil over period of time and ultimately their concentration is abnormally high as compared to other soil samples thereby rendering it unfit for human usage in any form. This accumulation not only destroys the local microbial population of the soil but also has major impact on large scale likedisturbing the food chain, leading to disturbed food web and ultimately affecting entire local ecosystem. The problem becomes much more severe when the availability of heavy metals is not only limited to the soil of the area, i.e. the effect is no longer local but would be widespread if the contamination is caused to the water source, rendering it unfit for human use in any form.

KEY WORDS: Soil, heavy metals, ICP-MS, pollutants

INTRODUCTION
Soil is considered to be the mixture of minerals, liquids, gases, decaying organic matter and wide variety of micro and macro organisms that altogether support various forms of life. It is the biologically active, porous medium that is capable of retaining water and forms the top most cover of Earth's crust. The general reference term for the soil is "pedolith".

According to the soil scientists, it is considered that soil is a set of three-state system: gases, liquids and solids wherein the minerals and organic matter form the solid phase and porous phase is composed of water (soil solution) and gases (soil atmosphere)[1].

The soil plays very vital role in the ecosystem and the four most important functions of soil worth mentioning are:

i. It provides a habitat to both macro and micro-organisms.

ii. It serves the purpose of growth medium for plants.

iii. Owing to its porous nature, it serves the purpose of water supply, purification and storage.

iv. Plants are supplied with nutrients and these nutrients are made available to the plants because of the reserving nature of soil particles, typically the clay particles and organic matter which holds the nutrients in place so that it can be taken up plants and utilized[2].

A typical soil sample is approximately 50% solid (45%- mineral, 5%- organic matter) and 50% pores (25%-water, 25%-gaseous content). The percentage of soil water content and gas content is varied whereas soil organic matter and mineral can be considered constant [3].

Five classic factors are considered to influence soil formation and evolution: parent material, time, climate, topography and organisms[4][5].

The soil profile[6] descriptions are valuable for deciding how the soil might be used and/or predicting how the soil might react to its intended use. By examining a soil profile, we can gain valuable insight into soil fertility. It also serves an important tool in nutrient management for understanding the available nutrient content of the soil in terms of various minerals and organic matters. Soil profile detailing iscrucial and important for estimating the probable use of soil or understanding the intended use of soil. Scientific detailing of the soil is not only useful for farming purposes but also for land use planners who require data to interpret whether the soil is fit for human dwelling and habitation or not, and scientists.

Heavy metals are considered to be metals that have relatively high densities, atomic numbers, or atomic weights. Density factor is generally taken as acceptable and commonly used reference criteria wherein a metal whose density is more than 5 g/cm^3 is called a heavy metal.The natural presence of heavy metals is comparatively scarce in the Earth's crust but due to anthropological activities, this amount has tremendously increased in the soil. The heavy metals find their use in various daily activities and products of daily use like car batteries, antiseptics, petrol and petroleum products, products made of plastic, solar panels, mobile phones, paints and particle accelerators.

As discussed earlier, the Earth's crust comprises of approximately 5% of heavy metals (weight by weight), out of which, iron takes the major stake accounting for 95% of this quantity of heavy metals. Remaining 95% of the Earth’s crust is made up of non-metals (approximately 75%) and light metals (approximately 20%). Even though the heavy metals are present in so small quality, they are available for their economic extraction on large scale level because of the natural phenomenon like erosion, mountain formation or related geological processes that concentrate the amount of heavy metals at a particular geofgraphiclocation[7].

Major avavialability of the heavy metals in the environment is in the form ofchalcophiles (ore-loving) or lithophiles (rock-loving). Chalcophile heavy metals are comparatively less reactive d-block elements. They can also belong to period 4–6 p-block metals and metalloids[8] and are usually present in form of insolublesulfide minerals. Their density is more than lithophiles and hence they tend to sink deep into the Earth’s crust upon solidification and owing to this reson, they are relatively less abundant than the lithophiles. Lithophile on the other hand, are heavy metals that mainly belong to f-block and the more reactive than the d-block elements. They have a strong affinity for oxygen and are majorly present in form of low density silicate minerals.

In addition to the natural occurrence of the heavy metals in trace amount, the abundance of heavy metal concentration in the earth may be accredited to the human activities such as mining, industrial effluent discharge, untreated waste discharge, leaded petrol and paint, untreated sewage, use of pesticides and fertilizers in farms and petrochemical wastes. Soil is

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considered to be the ultimate receptor of the pollutants resulting from discharge of various effluents in the environment as a result of different aforesaid anthropogenic activities. Unlike organic wastes, heavy metals do not undergo degradation by chemical or microbial action and hence get accumulated in particular soil over period of time and ultimately their concentration is abnormally high as compared to other soil samples thereby rendering it unfit for human usage in any form. This accumulation not only destroys the local microbial population of the soil but also has major impact on large scale likedisturbing the food chain, leading to disturbed food web and ultimately affecting entire local ecosystem. The possible ways of contamination by heavy metals are: absorption by plants, direct ingestion, food chains and consumption of contaminated water. The problem becomes much more severe when the availability of heavy metals is not only limited to the soil of the area, i.e. the effect is no longer local but would be widespread if the contamination is caused to the water source, rendering it unfit for human use in any form. The heavy metals possess a threat to lives and existence of plants, humans, animals and eventually whole ecosystems.

MATERIAL AND METHOD

Collection of the sample:

Soil sample collection site:

The experimental site covered the different areas of Gandhinagar. The sampling was carried out in industrial area, thermal power plant site, heavy traffic area and garden.The samples were collected from following sites-

1. Industrial area - Gujarat industrial development corporation, sector 28.
2. Thermal power plant area – Thermal power plant, sector 30.
3. Heavy traffic area – Pathikashram, near GH-3 circle.
4. Garden field - Infocity.

Soil sample collection:

The soil samples were collected from four different sites and each site had 10 different locations. There were in total 40 locations from where soil samples were collected. The samples were collected with the help of clean shovel and spatula. The soil sample was collected from the depth of 15 cm around the sample area. The soil was thoroughly mixed and then transferred into clean and labelled plastic zip bag for further analysis.

Analysis:

The soil samples were mixed and sieved through 2-mm mesh sieve and oven dried at 100 ℃ to dry out any moisture that would hinder in determining heavy metal contents from the sample.

Materials required: Soil samples, Plastic zip bag, Shovel and spatula, 2-mm- sieve, Measuring cylinder, Electronic weighing balance, Whatmann filter paper no. 25, Milli-Q water, Distilled water, Falcon tubes, Tissue paper

Chemicals required: 67 % high purity HNO_3, H_2O_2

Instruments required: Microwave digestor, ICP-MS with auto-sampler.

Extraction of metals:

1. 0.2g soil samples were weighed on butter paper using electric weighing balance.
2. 10 ml of nitric acid was measured and kept aside.
3. Soil sample and nitric acid were transferred into a closed Tefflon vessel of microwave digestion instrument and following procedure was followed: Mixture was heated at

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temperature of 210℃ for 20 minutes; this temperature was held for further 20 minutes at 1800 watt and finally after that 20 minutes of cooling was run.

4. After cooling, the solution was filtered out using Whatmann filter paper no. 44.
5. Finally, the filtrate was transferred to the falcon tube measuring 50mL.
6. The sample was then diluted to that volume (50 mL) using Milli-Q water and finally mixed thoroughly.

Analysis:

The Inductive Coupled Plasma Mass Spectroscopy was used for analysing the elements of interest from the chosen samples using kinetic energy discrimination (KED).

INSTRUMENTATION

The Inductive Coupled Plasma Mass Spectroscopy was used for analysing the elements of interest from the chosen samples using kinetic energy discrimination (KED). Operating conditions (parameter) of Inductively Coupled Plasma- Mass Spectrometryare as follows:

Operating Conditions	
Nebulizer gas flow	1.06ml/min
Plasma gas flow	18.00ml/min
Auxiliary gas flow	0.80ml/min
Deflector voltage	-11.00v
ICP RF Power	1550w
Analyser vacuum	5.0×10^{-7}

Table 1.1: *Operating conditions of Inductively Coupled Plasma- Mass Spectrometry (ICP- MS)*

Calibration of Instrument

Instrument was tune by using the tune solution Thermo4A REV (by Thermofisher) and Thermo5A solution was used for mass calibration of the instrument.

Standard Preparation

The standard provided by the Thermofisher is of 1000µl/ml, i.e, 1000ppm.

Firstly, a intermediate solution of 1ppm(1000ppb) is prepared from the standard solution(Thermofisher) from that 10ppb, 100ppb, 250ppb, 500ppb, 1000ppb standard was prepared.

- For blank 1% HNO_3 v/v is used.
- Preparation of intermediate standard solution of 1ppm=1000ppb.

$N_1V_1=N_2V_2$

N_1=1000ppm, N_2=1ppm, V_2=25ml, V_1=?

$1000\times V_1=1\times25$

V_1=1x25/1000

V_1=0.025ml

=0.025x1000µl

25µl of standard solution + 1% HNO_3 solution to make final volume 25ml.

- Preparation of 10ppb from intermediate standard solution of 1000ppb.

$N_1V_1=N_2V_2$

N_1=1000ppb, V_1 = ? N_2=10ppb, V_2=25ml

1000xV_1=10x25

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V_1=10x25/1000
V_1=0.25ml
=0.25x1000µl
250µl of intermediate standard solution + 1% HNO_3 solution to make final volume of 25ml.

- Preparation of 100ppb from intermediate standard solution of 1000ppb.

$N_1V_1 = N_2V_2$
N_1=1000ppb, V_1=? N_2=100ppb, V_2=25ml
1000xV_1=100x25
V_1=100x25/1000
V_1=2.5ml
2.5x1000µl
2500µl of intermediate standard solution + 1% HNO_3 solution to make final volume of 25 ml.

- Preparation of 250ppb from intermediate standard solution of 1000ppb.

$N_1V_1 = N_2V_2$
N_1=1000ppb, V_1=? N_2=250ppb, V_2=25ml
1000xV_1=250x25
V_1=250x25/1000
V_1=6.25ml
6.25x1000µl
6250µl of intermediate standard solution + 1% HNO_3 solution to make final volume of 25 ml.

- Preparation of 500ppb from intermediate standard solution of 1000ppb.

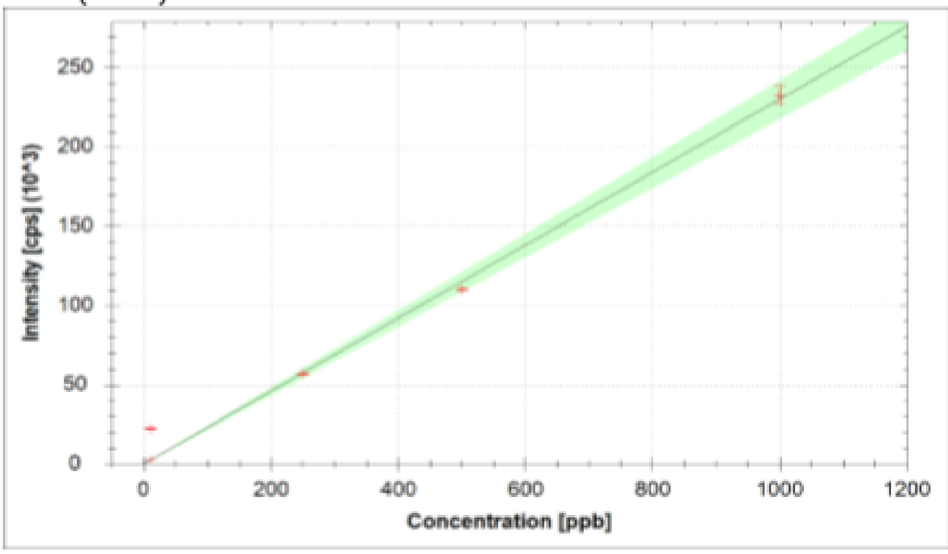
$N_1V_1 = N_2V_2$
N_1=1000ppb, V_1=? N_2=500ppb, V_2=25ml
1000xV_1=500x25
V_1=500x25/1000
V_1=12.5ml
12.5x1000µl
12500µl of intermediate standard solution + 1% HNO_3 solution to make final volume of 25 ml.

- Preparation of 1000ppb from intermediate standard solution of 1000ppb.

$N_1V_1 = N_2V_2$
N_1=1000ppb, V_1=? N_2=1000ppb, V_2=25ml
1000xV_1=1000x25
V_1=1000x25/1000
V_1=25ml
25x1000µl
25000µl of intermediate standard solution + 1% HNO_3 solution to make final volume of 25 ml.

CALIBRATION CURVES

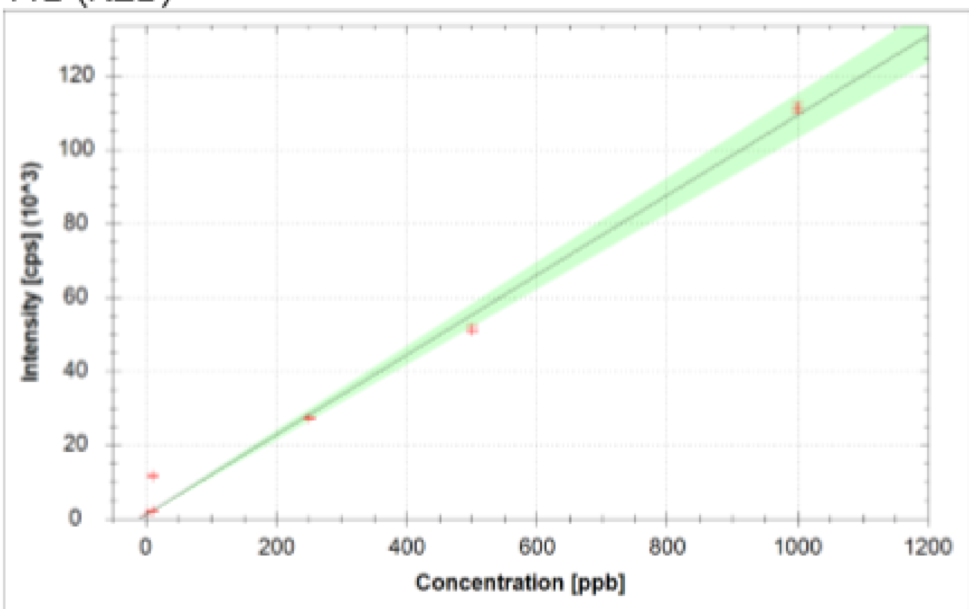
9Be (KED)



f(x) = 230.1796*x + 4.6667
R^2 = 0.9891
BEC = 0.020 ppb
LoD = 0.0398 ppb

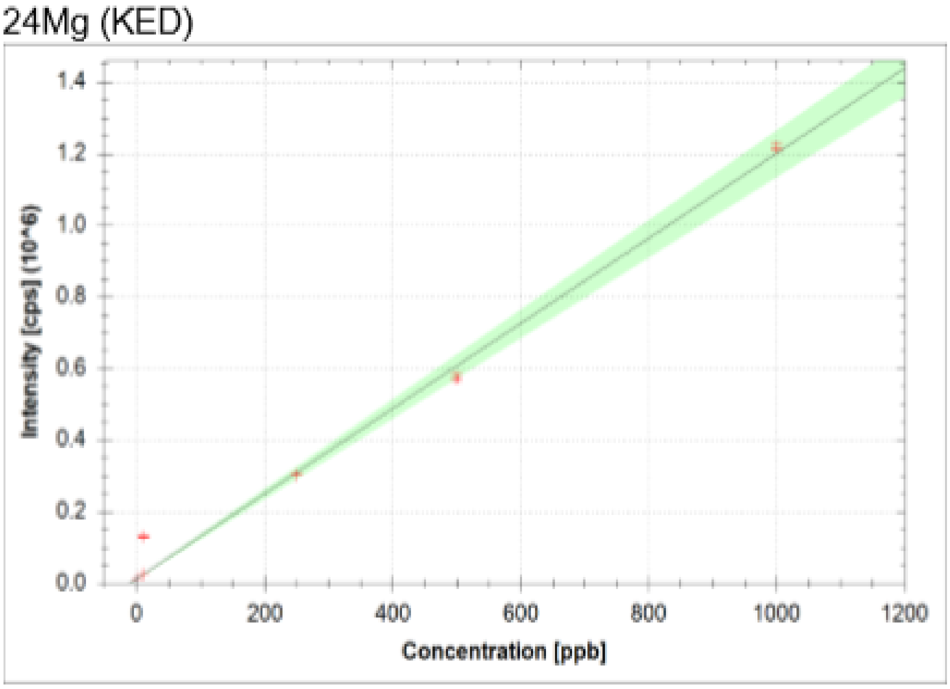
Figure1.1: *Calibration curve of Be*

11B (KED)



f(x) = 108.1357*x + 1166.7219
R^2 = 0.9881
BEC = 10.789 ppb
LoD = 1.1172 ppb

Figure1.2: *Calibration curve of B*



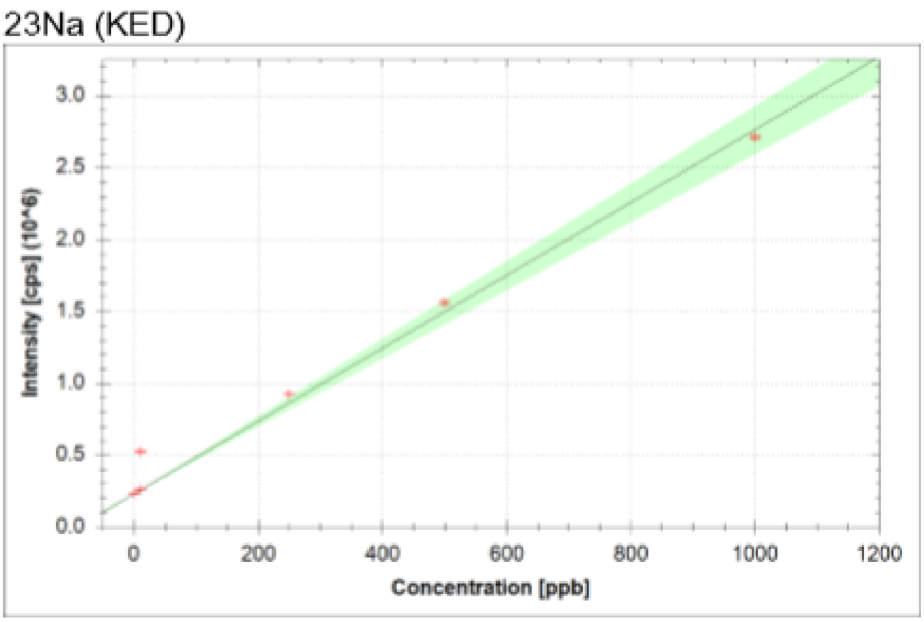
f(x) = 1187.1076*x + 13389.1955

R^2 = 0.9884

BEC = 11.279 ppb

LoD = 0.4044 ppb

Figur1.3: *Calibration curve of Mg*



f(x) = 2533.1875*x + 229968.6899

R^2 = 0.9823

BEC = 90.782 ppb

LoD = 2.0872 ppb

Figure1.4: *Calibration curve of Na*

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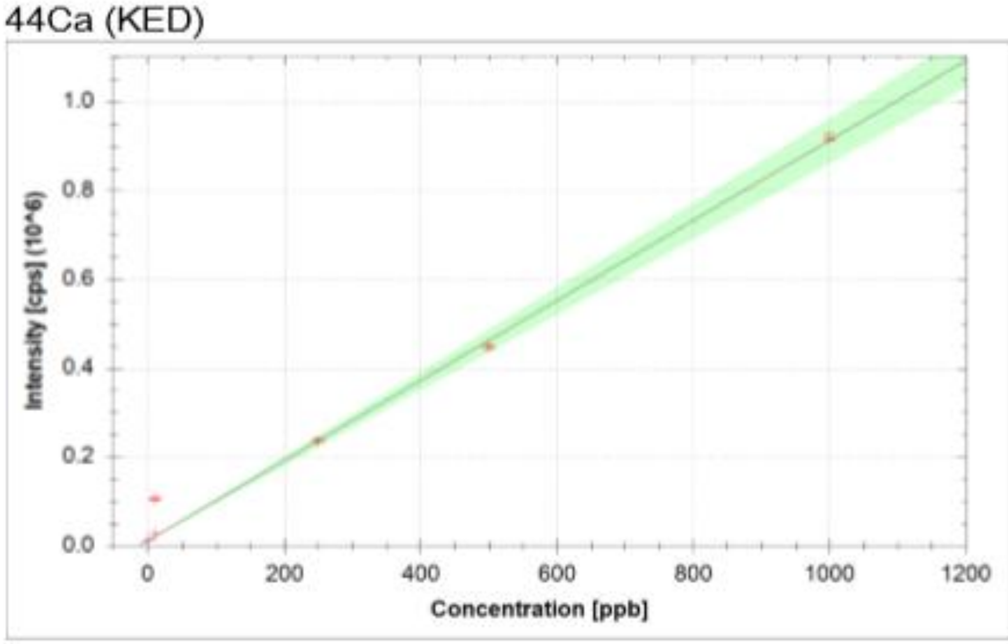


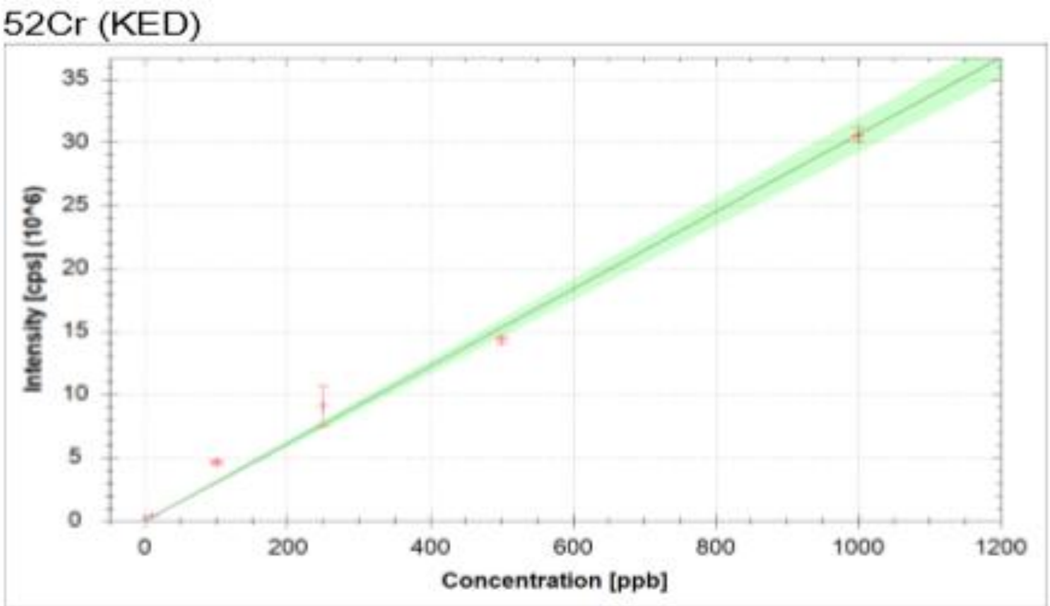
f(x) = 901.4495*x + 11380.5451

R^2 = 0.9877

BEC = 12.625 ppb

LoD = 0.5271 ppb

Figure1.5: *Calibration curve of Ca*



f(x) = 30591.6949*x + 5934.7470

R^2 = 0.9916

BEC = 0.194 ppb

LoD = 0.0015 ppb

Figure1.6: *Calibration curve of Cr*

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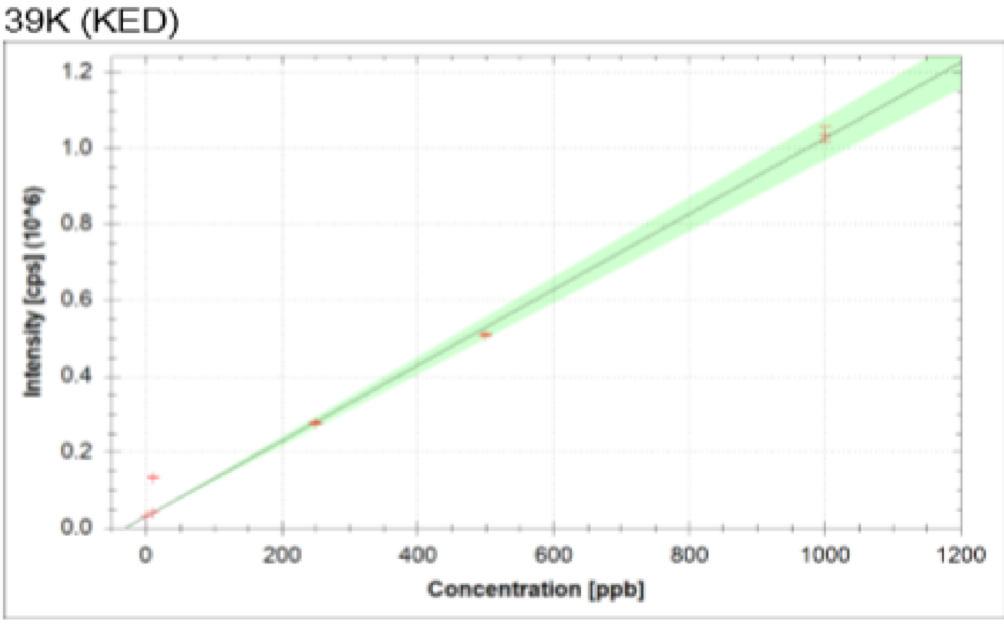


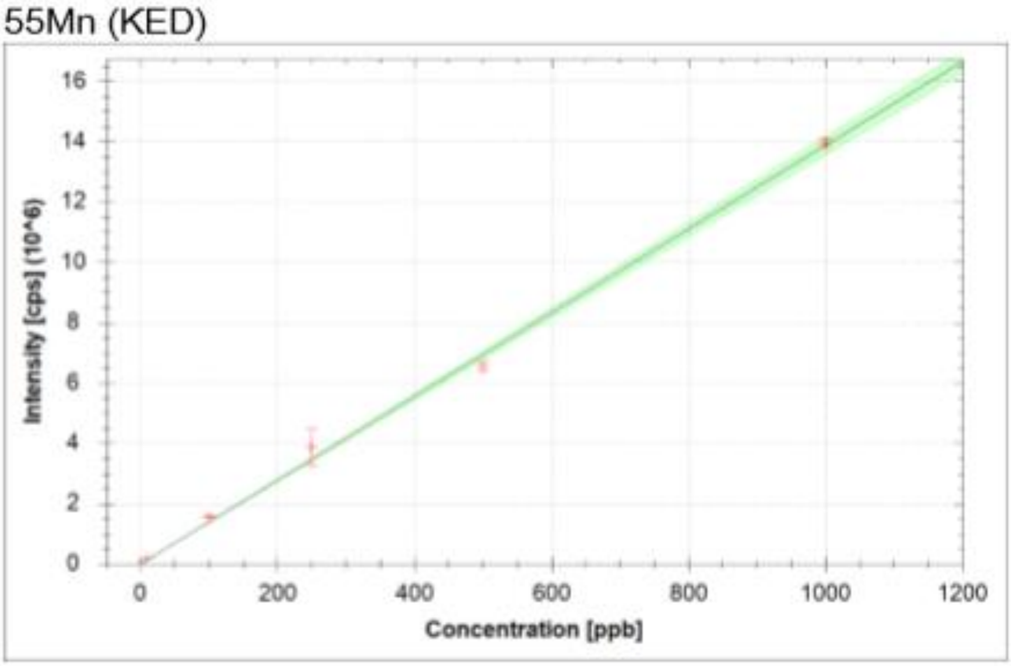
f(x) = 995.5663*x + 30908.9089

R^2 = 0.9879

BEC = 31.047 ppb

LoD = 0.6986 ppb

Figure1.7: *Calibration curve of K*



f(x) = 13877.9447*x + 2892.3361

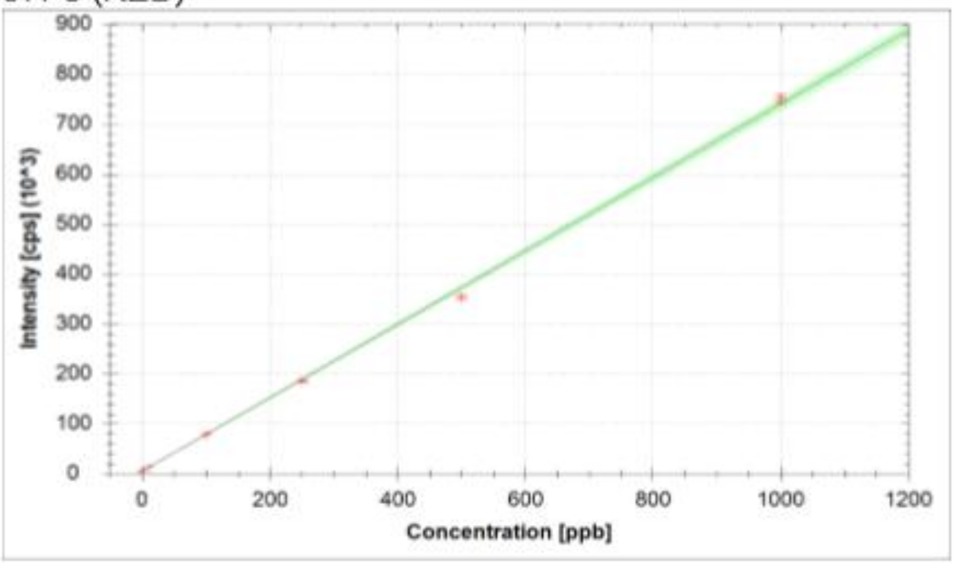
R^2 = 0.9975

BEC = 0.208 ppb

LoD = 0.0097 ppb

Figure1.8: *Calibration curve of Mn*

57Fe (KED)



f(x) = 735.6669*x + 5401.1736

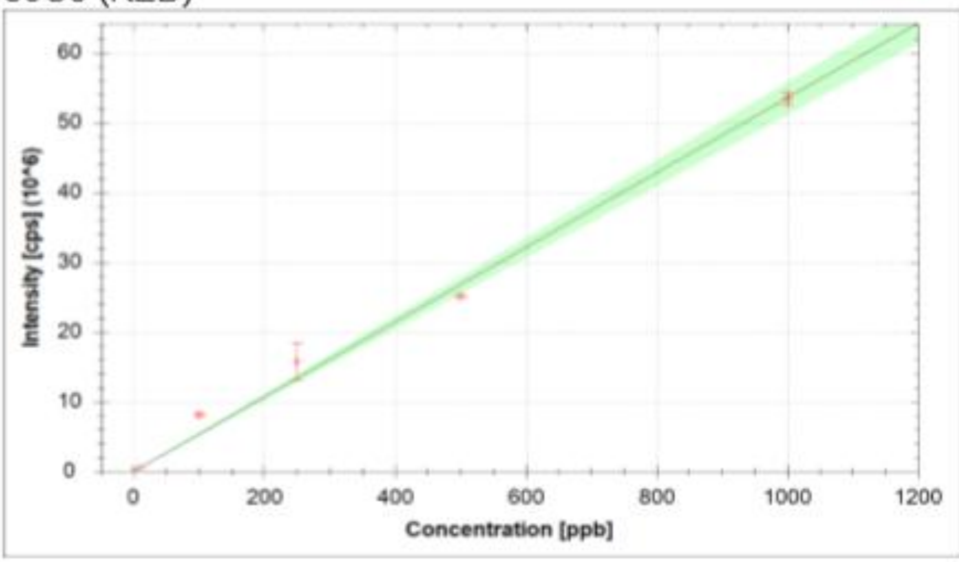
R² = 0.9987

BEC = 7.342 ppb

LoD = 0.4164 ppb

Figure1.9: *Calibration curve of Fe*

59Co (KED)



f(x) = 53563.4796*x + 574.0138

R² = 0.9922

BEC = 0.011 ppb

LoD = 0.0038 ppb

Figure1.10: *Calibration curve of Co*

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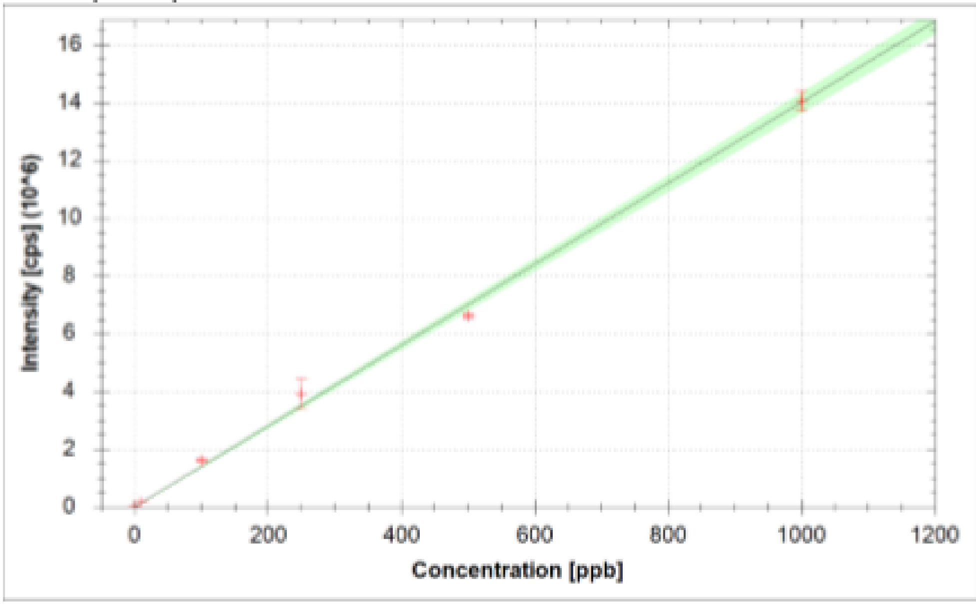
60Ni (KED)



f(x) = 13997.2948*x + 5352.4875

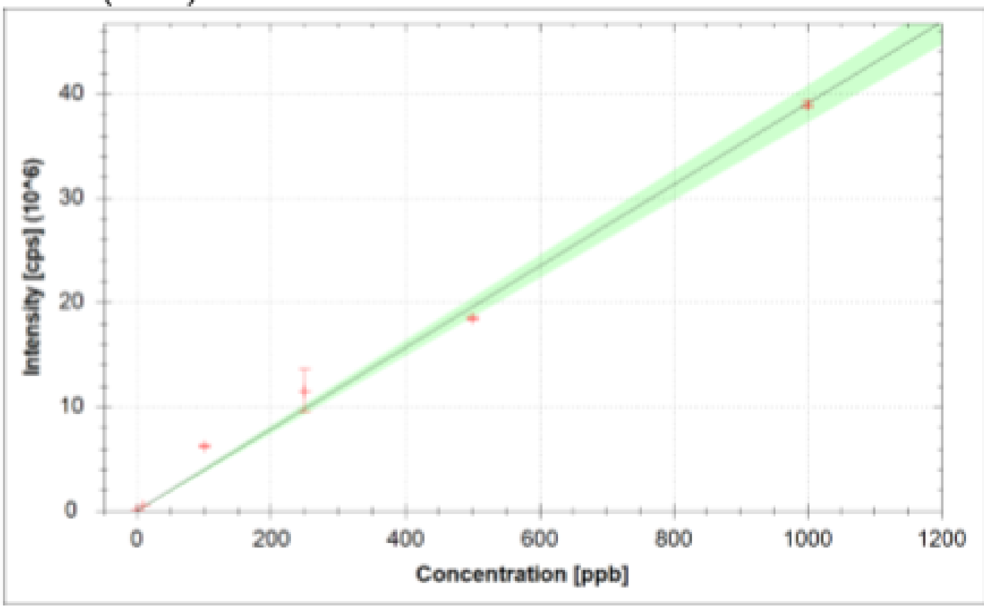
$R^2 = 0.9975$

BEC = 0.382 ppb

LoD = 0.0320 ppb

Figure1.11: *Calibration curve of Ni*

63Cu (KED)



f(x) = 39015.3866*x + 58032.0318

$R^2 = 0.9914$

BEC = 1.487 ppb

LoD = 0.0926 ppb

Figure1.12: *Calibration curve of Cu*

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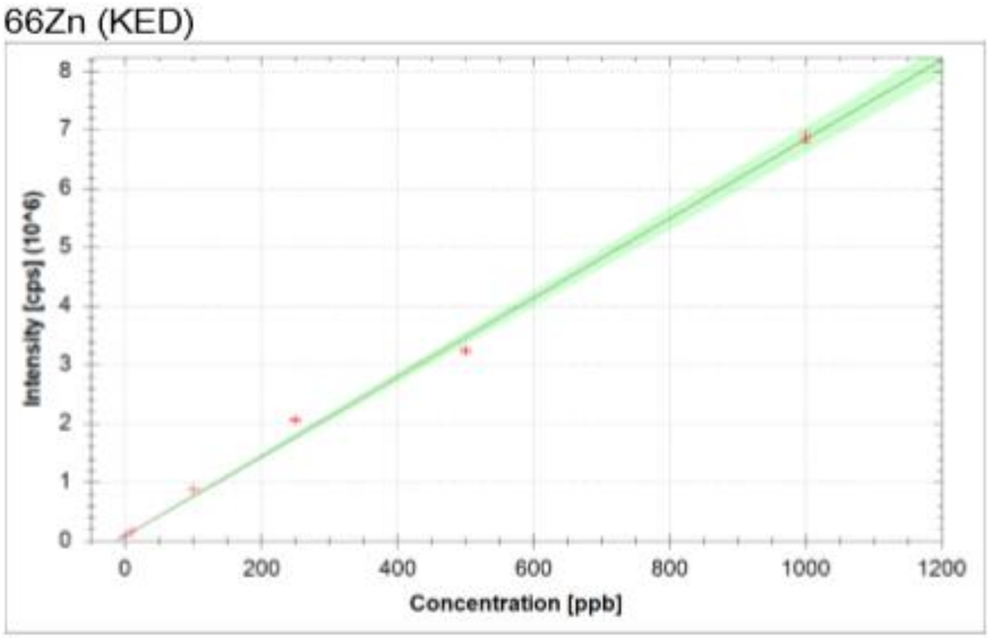
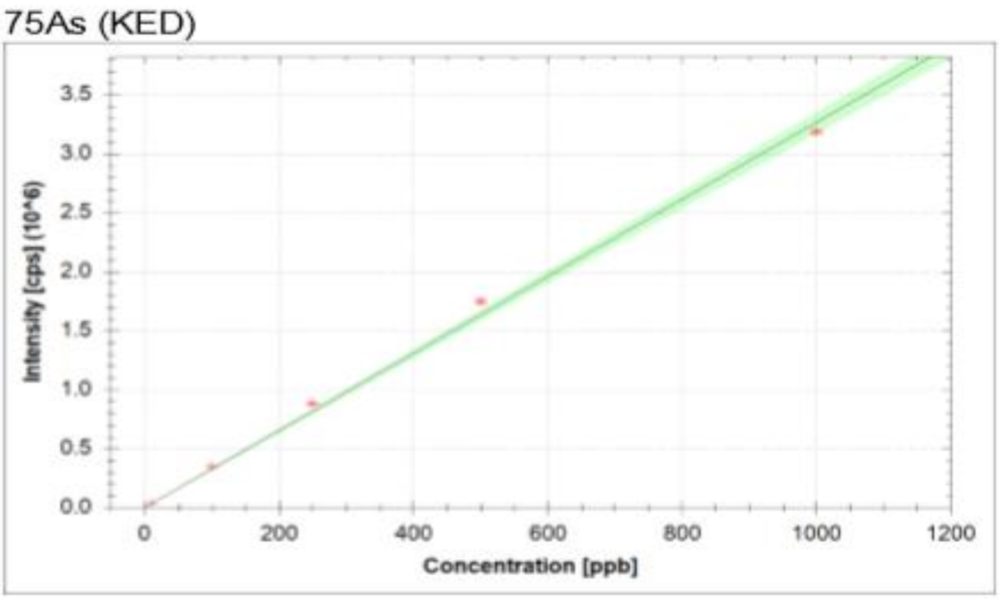


f(x) = 6753.7856*x + 85802.6556
R^2 = 0.9955
BEC = 12.704 ppb
LoD = 0.2734 ppb

Figure1.13: *Calibration curve of Zn*



f(x) = 3265.5113*x + 42.6668
R^2 = 0.9969
BEC = 0.013 ppb
LoD = 0.0056 ppb

Figure1.14: *Calibration curve of As*

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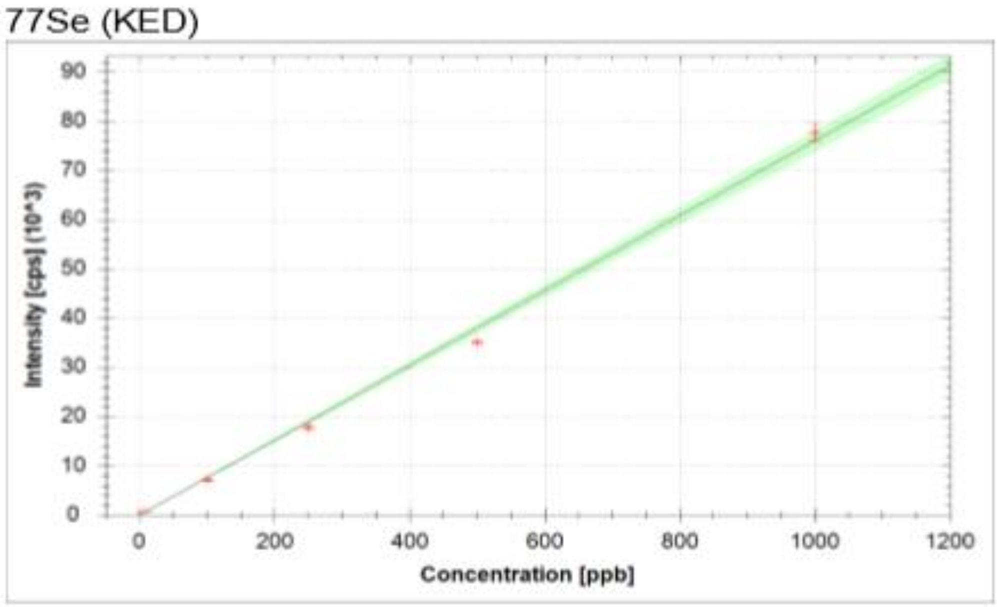


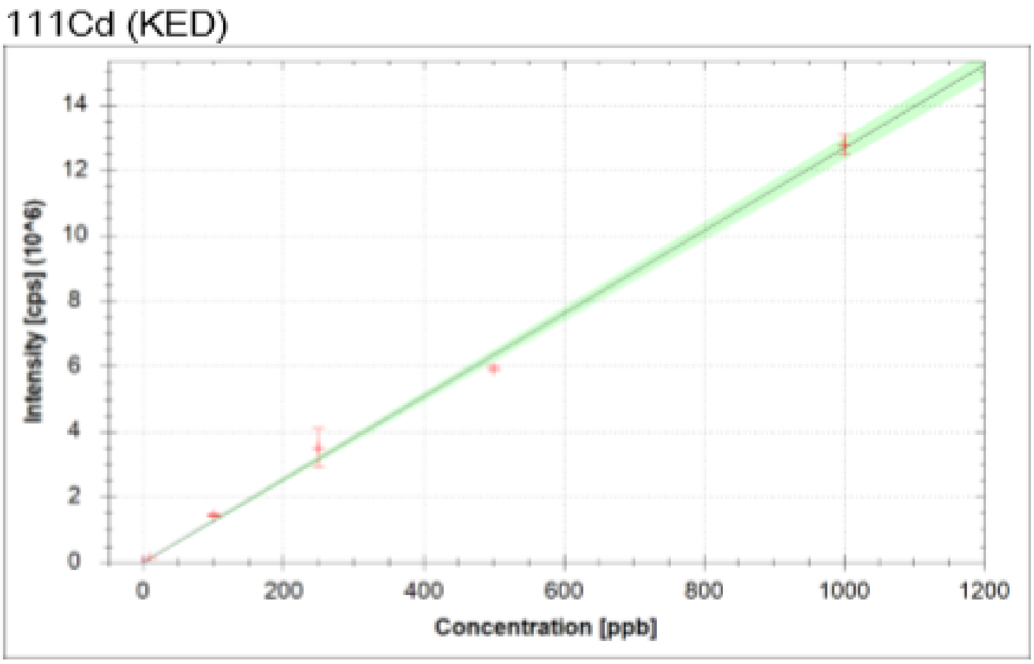
f(x) = 76.0146*x + 2.0000

R^2 = 0.9970

BEC = 0.026 ppb

LoD = 0.0000 ppb

Figure1.15: *Calibration curve of Se*



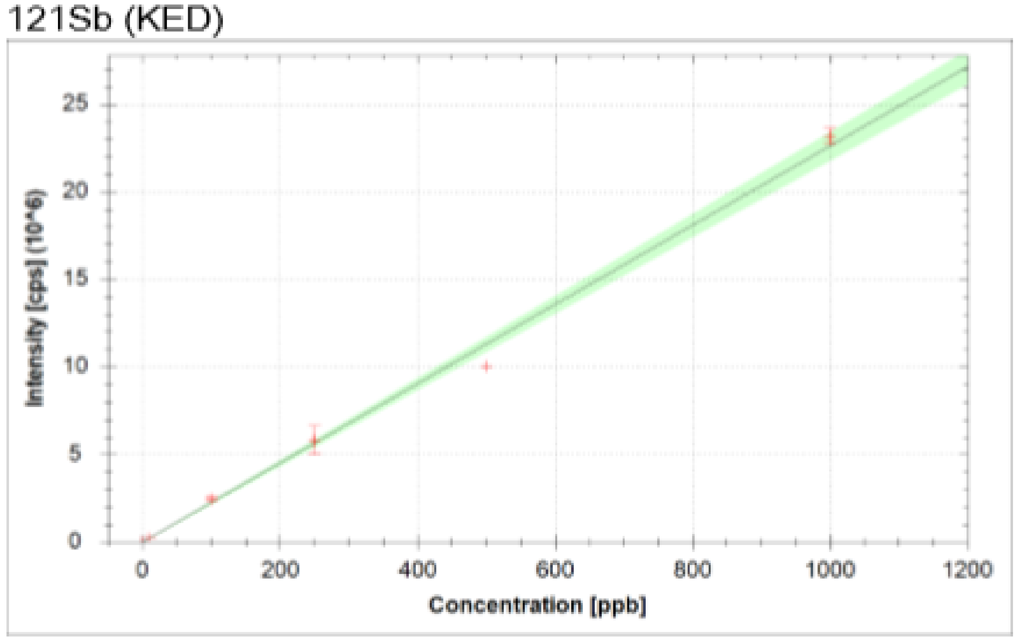
f(x) = 12675.0500*x + 1131.3856

R^2 = 0.9973

BEC = 0.089 ppb

LoD = 0.0095 ppb

Figure1.16: *Calibration curve of Cd*



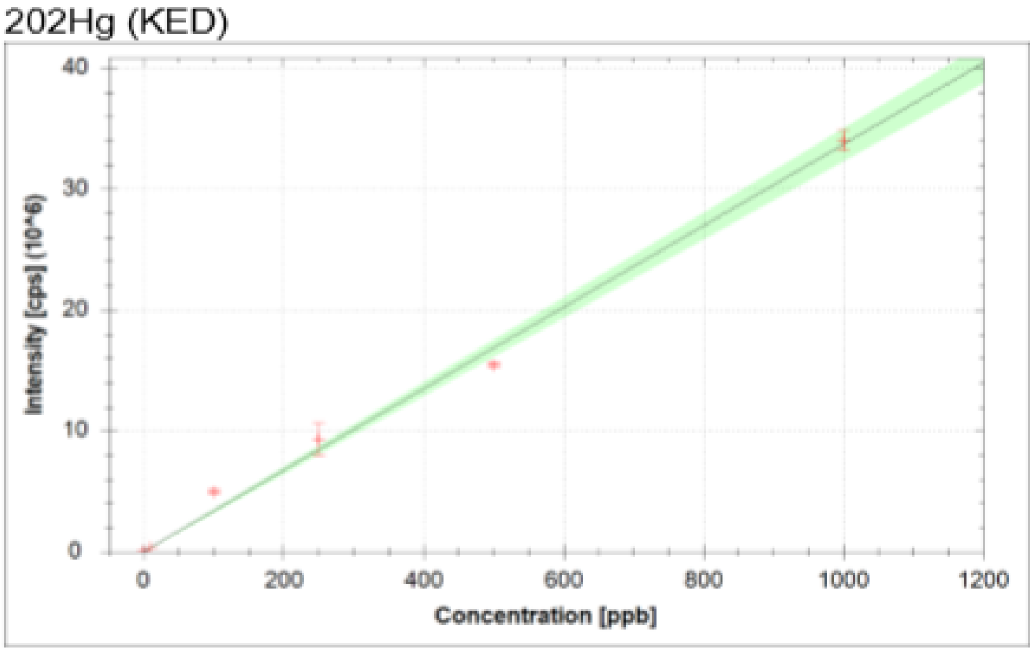
f(x) = 22607.5204*x + 2352.8903

R^2 = 0.9950

BEC = 0.104 ppb

LoD = 0.0028 ppb

Figure1.17: *Calibration curve of Sb*



f(x) = 33681.5365*x + 23234.3070

R^2 = 0.9935

BEC = 0.690 ppb

LoD = 0.0290 ppb

Figure1.18: *Calibration curve of Hg*

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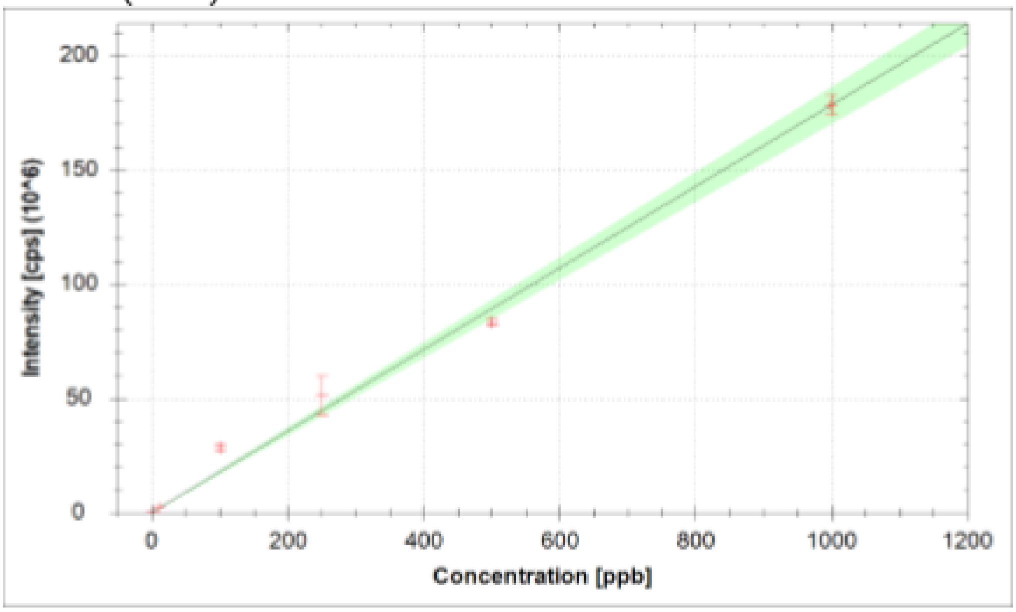
208Pb (KED)



f(x) = 178238.2400*x + 165302.2327

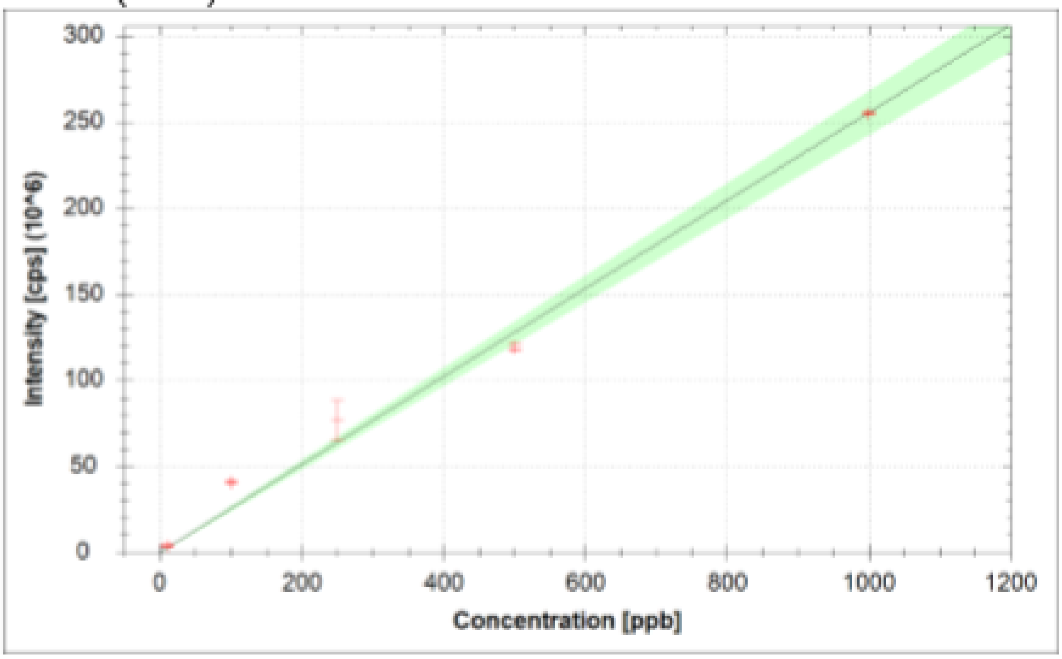
R^2 = 0.9916

BEC = 0.927 ppb

LoD = 0.0192 ppb

Figure1.19: *Calibration curve of Pb*

209Bi (KED)



f(x) = 255523.2478*x + 13403.2094

R^2 = 0.9895

BEC = 0.052 ppb

LoD = 0.0034 ppb

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Figure1.20: *Calibration curve of Bi*

RESULT

Soil Sample: Infocity (L1) (Concentration in ppb)										
S.No.	**Be**	**B**	**Na**	**Mg**	**K**	**Ca**	**Cr**	**Mn**	**Fe**	**Co**
S1	1.19	23.537	2906.297	8606.441	8290.13	2016.972	100.441	830.079	38387.9	19.764
S2	0.796	21.286	1813.076	5976.591	5531.388	3580.464	93.942	586.807	27111.1	13.451
S3	1.579	39.116	3270.392	14132.554	12061.58	2350.822	157.136	1270.23	53237.701	28.635
S4	1.373	22.519	1628.889	10602.81	8276.281	1732.687	116.301	935.986	39443.733	21.693
S5	1.214	30.173	2572.936	11045.115	9809.702	3312.71	124.838	1159.248	43431.996	25.394
S6	0.979	16.895	1276.076	6548.806	6251.824	1640.528	80.918	642.598	26535.179	15.079
S7	1.075	18.98	1620.226	7363.393	7031.362	2305.3355	88.347	770.483	32313.09	16.7
S8	2.033	32.368	1791.295	11882.822	12316.142	1916.752	181.251	1467.685	55756.592	30.194
S9	1.445	27.743	1841.423	8579.475	8206.597	1851.562	127.314	946.583	36833.95	19.706
S10	1.718	29.895	1786.694	14196.373	14123.204	2916.887	182.716	1474.333	62563.907	32.395
Total	**13.402**	**262.512**	**20507.304**	**98934.38**	**91898.21**	**23624.7195**	**1253.204**	**10084.032**	**415615.148**	**223.011**

The resultant concentration of heavy metals in ppb (parts per billion) in the soil samples that were collected is listed in the tables given below:

Table 2.1-a: *Soil samples from Infocity- L1*

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Soil Sample: Infocity(L1) (Concentration in ppb)										
S.No.	**Ni**	**Cu**	**Zn**	**As**	**Se**	**Cd**	**Sb**	**Hg**	**Pb**	**Bi**
S1	83.954	53.896	123.839	9.798	62.754	3.734	0.755	81.407	32.177	1.296
S2	48.932	29.272	50.424	7.511	62.956	3.571	0.308	85.436	15.53	0.85
S3	88.125	55.847	147.799	14.196	84.804	4.355	0.053	96.007	30.356	1.246
S4	64.233	37.775	72.383	11.417	67.027	3.033	-0.031	85.345	20.007	0.848
S5	72.732	48.268	145.438	11.783	71.528	4.034	0.357	91.548	29.11	1.076
S6	50.387	26.542	56.955	8.258	47.042	2.05	-0.016	57.232	15.774	0.644
S7	52.26	30.819	60.308	9.589	59.315	3.163	0.205	88.2	17.866	0.784
S8	89.325	123.918	167.091	15.239	90.832	3.566	0.058	83.805	32.067	1.082
S9	60.18	37.264	134.628	10.614	59.026	3.617	-0.058	79.882	22.75	0.86
S10	91.416	57.462	157.474	14.427	98.599	5.222	0.069	113.111	37.55	1.343
Total	**701.544**	**501.063**	**1116.339**	**112.832**	**703.883**	**36.345**	**1.7**	**861.973**	**253.187**	**10.029**

Table 2.1-b: *Soil samples from Infocity- L1*

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Soil Sample: Thermal Power Plant (L2) (Concentration in ppb)										
S.No.	**Be**	**B**	**Na**	**Mg**	**K**	**Ca**	**Cr**	**Mn**	**Fe**	**Co**
S1	1.486	55.665	2520.878	9980.273	10661.322	3003.688	171.671	1195.184	58799.492	29.818
S2	1.665	19.769	1470.396	9017.589	7106.472	4451.62	115.88	963.929	47964.33	23.114
S3	1.185	30.068	2666.005	12044.889	6942.595	5021.495	182.314	1200.7	51132.508	25.704
S4	1.411	16.741	1188.683	9636.671	6754.831	5533.42	118.666	998.299	48801.343	24.767
S5	1.046	15.946	1227.098	7451.801	5225.327	3814.242	101.187	881.097	40110.153	19.004
S6	1.411	30.697	2282.314	9327.169	10142.592	1555.027	136.708	1203.429	47963.168	24.98
S7	1.512	21.446	1785.422	11280.681	8433.143	1391.533	135.054	1197.848	51331.018	29.154
S8	1.689	28.927	3175.659	12432.382	10125.005	7382.381	120.559	999.841	48891.819	25.147
S9	1.857	27.712	1178.903	9631.376	12872.425	1609.578	139.069	1090.258	40742.449	24.997
S10	2.054	27.181	1702.856	12406.805	13869.963	1321.005	175.424	1473.068	57177.363	33.002
Total	**15.316**	**274.152**	**19198.214**	**103209.636**	**92133.675**	**35083.989**	**1396.532**	**11203.653**	**492913.643**	**259.687**

Table 2.2-a: *Soil samples from Thermal power plant- L2*

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Soil Sample: Thermal Power Plant (L2) (Concentration in ppb)										
S.No.	**Ni**	**Cu**	**Zn**	**As**	**Se**	**Cd**	**Sb**	**Hg**	**Pb**	**Bi**
S1	79.887	61.253	173.569	15.531	90.165	4.3	-0.011	94.172	31.838	1.079
S2	64.229	55.769	150.635	10.819	69.036	3.748	-0.018	89.376	27.53	0.934
S3	56.269	79.485	277.053	8.239	61.781	4.734	0.009	98.427	35.994	1.138
S4	67.736	58.039	130.424	12.565	63.123	4.152	0.025	93.409	28.321	0.992
S5	60.004	55.514	210.017	8.174	53.604	4.158	0.007	86.695	29.098	0.915
S6	72.58	49.897	114.415	11.736	77.486	4.606	0.021	101.079	32.5	1.143
S7	90.967	57.698	116.593	13.541	75.915	4.486	0.781	100.254	31.41	1.138
S8	55.074	58.43	285.03	9.358	69.563	6.713	0.489	91.532	434.249	1.211
S9	90.206	48.246	148.98	10.84	58.438	3.341	0.387	77.856	26.589	0.827
S10	98.338	59.859	124.955	14.457	114.325	4.668	0.52	101.618	35.833	1.259
Total	**735.29**	**584.19**	**1731.671**	**115.26**	**733.436**	**44.906**	**2.21**	**934.418**	**713.362**	**10.636**

Table 2.2-b: *Soil samples from Thermal power plant- L2*

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Soil Sample: Pathikashram (L3) (Concentration in ppb)										
S.No.	**Be**	**B**	**Na**	**Mg**	**K**	**Ca**	**Cr**	**Mn**	**Fe**	**Co**
S1	1.315	21.434	1370.859	8868.514	7747.434	1700.501	116.025	1023.683	40172.585	21.689
S2	1.289	18.048	1519.028	9448.112	8615.242	4613.371	108.766	877.962	36026.057	19.718
S3	1.428	16.328	1105.438	8590.51	8645.679	958.106	122.164	1061.365	42287.646	22.954
S4	1.492	26.472	1647.622	13064.941	12334.281	2745.036	146.6	1190.506	49201.64	27.17
S5	0.753	6.696	957.444	5196.23	4151.193	1651.218	63.574	566.768	25281.985	13.501
S6	1.422	17.974	2030.59	9228.818	9743.24	1785.378	124.114	1112.707	42949.196	24.776
S7	0.414	1.8	690.589	2617.309	2149.781	1115.531	43.805	294.288	12695.914	6.681
S8	1.744	22.421	1901.763	10926.364	11115.859	2272.132	145.328	1218.548	49565.577	27.18
S9	1.306	18.542	1705.479	7506.727	7234.338	1818.511	115.106	887.053	36331.923	19.052
S10	1.712	25.097	2551.52	11746.688	12979.823	3484.333	159.965	1412.441	56853.066	29.209
Total	**12.875**	**174.812**	**15480.332**	**87194.213**	**84716.87**	**22144.117**	**1145.447**	**9645.321**	**391365.589**	**211.93**

Table 2.3-a: *Soil samples from Pathikashram- L3*

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Soil Sample: Pathikashram (L3) (Concentration in ppb)										
S.No.	**Ni**	**Cu**	**Zn**	**As**	**Se**	**Cd**	**Sb**	**Hg**	**Pb**	**Bi**
S1	65.366	58.797	93.32	12.009	76.363	3.617	0.042	85.048	28.541	1.118
S2	58.218	43.835	99.525	10.217	66.931	3.551	0.117	88.637	27.735	0.873
S3	69.341	40.157	74.212	11.356	70.151	3.547	-0.028	84.235	22.718	0.957
S4	77.255	61.022	171.704	11.524	71.555	3.961	0.001	82.281	37.448	0.989
S5	37.359	38.835	76.644	6.247	40.48	2.398	-0.014	69.049	16.873	0.567
S6	72.059	55.3529	132.556	11.401	69.572	3.534	0.06	90.083	29.995	0.911
S7	19.819	13.747	18.764	4.267	26.506	1.377	-0.06	42.314	8.582	0.328
S8	76.069	56.563	103.196	13.677	83.909	4.544	0.008	98.438	32.657	1.15
S9	54.364	37.357	76.851	11.002	67.29	3.563	0.006	81.488	22.335	0.94
S10	79.364	61.561	116.36	12.914	80.785	4.48	-0.011	98.96	30.85	1.141
Total	**609.214**	**467.2269**	**963.132**	**104.614**	**653.542**	**34.572**	**0.121**	**820.533**	**257.734**	**8.974**

Table 2.3-b: *Soil samples from Pathikashram- L3*

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Soil Sample: Gujarat Industrial Development Corporation (L4) (Concentration in ppb)										
S.No.	**Be**	**B**	**Na**	**Mg**	**K**	**Ca**	**Cr**	**Mn**	**Fe**	**Co**
S1	1.037	17.82	2045.456	9295.061	7745.575	3675.735	114.505	874.239	39111.844	20.424
S2	1.466	24.036	2955.011	17381.093	9956.374	7164.522	175.282	2122.871	118386.02	42.128
S3	1.254	19.578	1733.837	9862.445	7851.127	3093.519	156.655	1719.326	83477.032	26.556
S4	1.156	27.292	3165.654	9182.954	7947.303	4982.175	250.89	954.732	46049.419	26.669
S5	0.904	22.414	5518.445	13593.881	6478.337	4967.694	155.83	2753.988	162992.91	34.285
S6	1.205	18.733	1868.103	9958.758	6623.767	5793.119	90.3	729.528	40808.303	22.433
S7	1.428	24.357	7235.026	11513.788	9149.478	7890.41	140.94	1234.2	54861.485	26.116
S8	1.173	22.032	1828.132	9393.804	9439.177	2711.808	163.438	1131.949	63833.44	25.083
S9	1.187	25.424	5917.696	10753.622	7564.291	11724.214	835.816	3496.783	248871.606	40.009
S10	0.846	24.086	2713.84	6649.482	6307.635	3243.79	99.511	915.548	50645.872	16.1
Total	**11.656**	**225.772**	**34981.2**	**107584.888**	**79063.064**	**55246.986**	**2183.167**	**15933.164**	**909037.931**	**279.803**

Table 2.4-a: *Soil samples from GIDC- L4*

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Soil Sample: Gujarat Industrial Development Corporation (L4) (Concentration in ppb)										
S.No.	**Ni**	**Cu**	**Zn**	**As**	**Se**	**Cd**	**Sb**	**Hg**	**Pb**	**Bi**
S1	66.363	79.72	336.505	10.16	60.877	5.202	0.347	86.054	70.457	0.98
S2	97.05	134.253	2471.447	13.808	79.276	4.877	0.421	91.264	87.273	1.084
S3	77.279	99.708	5204.037	19.244	73.95	4.592	0.507	95.961	110.387	1.473
S4	116.23	1456.507	536.083	11.229	87.621	4.637	0.674	86.749	837.536	1.035
S5	76.552	222.563	3122.066	9.983	50.814	4.693	0.753	84.431	80.323	0.868
S6	53.665	41.922	134.341	9.827	68.896	4.013	0.414	91.611	24.852	0.975
S7	73.582	50.055	233.487	14.551	77.521	4.35	0.375	96.217	27.869	1.068
S8	69.243	86.489	479.473	12.309	88.498	4.773	0.215	83.243	155.909	3.029
S9	185.647	143.109	756.138	18.072	72.985	4.467	0.442	87.838	223.675	0.847
S10	52.208	48.252	327.984	8.705	54.288	3.911	0.635	91.334	28.259	1.049
Total	**867.819**	**2362.578**	**13601.561**	**127.888**	**714.726**	**45.515**	**4.783**	**894.702**	**1646.54**	**12.408**

Table 2.4-b: *Soil samples from GIDC- L4*

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S.No.	Elements	Average concentration in ppb			
		L1	L2	L3	L4
1.	Be	1.3402	1.5316	1.2875	1.1656
2.	B	26.2512	27.4152	17.4812	22.5772
3.	Na	2050.73	1919.821	1548.033	3498.12
4.	Mg	9893.438	10320.96	8719.421	10758.49
5.	K	9189.821	9213.368	8471.687	7906.306
6.	Ca	2362.472	3508.399	2214.412	5524.699
7.	Cr	125.3204	139.6532	114.5447	218.3167
8.	Mn	1008.403	1120.365	964.5321	1593.316
9.	Fe	41561.51	49291.36	39136.56	90903.79
10.	Co	22.3011	25.9687	21.193	27.9803
11.	Ni	70.1544	73.529	60.9214	86.7819
12.	Cu	50.1063	58.419	46.72269	236.2578
13.	Zn	111.6339	173.1671	96.3132	1360.156
14.	As	11.2832	11.526	10.4614	12.7888
15.	Se	70.3883	73.3436	65.3542	71.4726
16.	Cd	3.6345	4.4906	3.4572	4.5515
17.	Sb	0.17	0.221	0.0121	0.4783
18.	Hg	86.1973	93.4418	82.0533	89.4702
19.	Pb	25.3187	71.3362	25.7734	164.654
20.	Bi	1.0029	1.0636	0.8974	1.2408

Table 2.5: *Average concentration of elements in soil samples from different locations- L1, L2, L3 and L4*

DISCUSSION

In this study result shows the variation in the soil samples of pathikasram, thermal power plant, G.I.D.C and infocity area.

The results of the study revealed that the concentration of heavy metals in the soil sample of Gujarat industrial development corporation (G.I.D.C) in higher concentration. This is due to fact that the area is contaminated by the industrial effluents from the nearby industries. This may be due to anthropogenic activities like releasing of industrial wastage. Next to G.I.D.C, thermal power plant soil sample had the higher heavy metal concentration in it and infocity soil samples have the least.

The higher concentration of heavy metals not only diminish soil quality, but also can lead to human intake through the tropic food web and harm human beings and animals.

CONCLUSION

It was evidently concluded from this study that the soil from various sites of Gandhinagar area can be very useful for environmental toxicology study. This experiment proves that analysis of soil sample for heavy metals is valuable evidence. The urbanizationgrowth is occurring at a fast pace and has become worldwide trend. Crediting to this very trend and increased anthropogenic activities contributing for heavy metal contamination in soil, especially in the industrial and developing regions, where the major labour class population dwellings are near the industries, this topic has become a major area of interest for researchers.

Heavy metal provides a unique fingerprint of any soil and can help in specific soil profiling, much like individualization of any person using fingerprints. It provides unique soil profile from one region to another region which helps in forensic investigation also wherein the need is felt to determine the source of origin of soil sample. Moreover, it is a trending topic of Forensic environmental toxicology wherein establishing the cause of contamination will help the law suits in filing the case against the industries which will help in prevention of soil contamination by effluent discharge of the industrial waste. Moreover, as the population of the world is increasing, the statistics from this study may also help in identifying the probable effective remedial steps for the decontamination of soil so thatit can be made fit for the use for various purposes.

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