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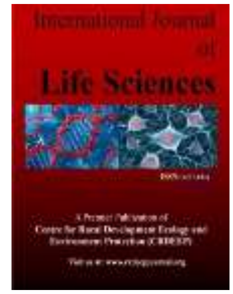

Full Length Research Paper

Spatial and Temporal Evaluation of Heavy metals on Biotic and Abiotic components at Kolar Gold Fields Gold Ore Tailings

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ABSTRACT

Heavy metals are bio transferred and bio accumulated both by natural and anthropogenic sources. The contamination by heavy metals in plants is one of the major concerns to be faced by the human mankind and requires attention because heavy metals above their normal ranges are extremely detrimental to both flora and fauna life. At Kolar Gold Fields,India, underground gold mining was carried out for more than a century resulting in tonnes of gold ore tailings. In the present study, water and plant samples spinach (Spinacia oleracea) were randomly collected from four different agricultural sites of Oorgaum, Tenants, Champion and Balghat mining regions to analyze various physio-chemical properties. Analysis was carried out twice during 2019 (January and July). Water and plant sample spinach (Spinacia oleracea) were randomly collected from four different agricultural sites of Oorgaum, Tenants, Champion and Balghat mining regions. The sampling and processing procedures were in accordance with the Slovak standards STN ISO 10381, and Decree No.338/2005. Heavy metals for which these samples were analysed were arsenic, cadmium, iron, nickel, chromium, copper, lead and manganese. Plant samples were studied separately for their root, stem and leaves. ICP-OES was used to analyse each of these samples. Results showed that concentrations of As, Ni and Cu were below permissible limits set by WHO, whereas Cd was recorded above the permissible limits at Champion and Balghat regions in water samples. Hardness and electrical conductivity of all water samples were recorded above the normal range 239 mg/ml and 1237 µS/cm *respectively, whereas pH of all water samples was recorded below the normal range, pH of all soil samples was recorded below the normal range while electrical conductivity of all soil samples was recorded above the normal range set by WHO. In plant samples the mean concentrations of heavy metal cadmium was high in Oorgaum and Tenants in all parts of plant, whereas average chromium levels were high in leavesat 1.495 mg/Kg of Champion and Tenants, Balghat and Oorgaum had high levels of chromium in roots. Lead was observed in significant levels in roots of Balghat and Champion samples. Mn and Fe was found in high concentration at 7.1* mg/kg *in leaves and roots of spinach plant collected from Balghat and Champion sites respectively. The elevate levels of heavy metals in water and plant samples in certain regions of the study area acts as a base line data for further quality assessment for domestic and agricultural usage.*

Introduction

Anthropogenic activities such as mining, industrial production, agriculture and transportation, release high amounts of heavy metals into surface and ground water, soils and ultimately to the biosphere. Accumulation of heavy metals in crop plants is of great concern due to the probability of food contamination through the soil root interface. Even though the heavy metals like arsenic, cadmium, nickel are non-essential elements they are readily taken up and accumulated by various plants in harmful forms. Consumption of vegetables grown amidst contaminated water and soil can pose huge threat to higher animals in ecological pyramid. Anthropogenic activities such as mining, smelting and manufacturing industries, agriculture contributes at large to environmental pollution [L.Jantschi et al 2008, C,Stihi et al 2006].Therefore, the determination of permitted metal ions in soil, water becomes imperative. Contrariwise, metals also occur in small quantities naturally and may enter into aquatic system through leaching of rocks, airborne dust, forest fires and vegetation. As heavy metals cannot be degraded, they are unceasingly being dumped and incorporated in water, thus causing heavy metal pollution in water bodies. The presence of heavy metals in the water may have a profound effect on the crops cultivated nearby. K.G.F or Kolar Gold Fields is a town in Bargarpet taluk, in the Kolar district of state Karnataka, India. The Kolar Gold Fields gold mines are located towards the southern end of a narrow strip of schist, latitude: 12º53'12'' N, longitude 78º 15' 03'' E. It includes the township of same name, viz. KGF, residents are mainly the families of gold mine employees. At KGF, underground gold mining was carried out for more than a century, gold has been mined to a depth of 3 kilometers below the surface with 65 kilometers of tunnel work and 40 million tons of mill tailings are accumulated, which has covered about 4 square kilometers of the area. The present study was done to assess the presence of heavy metals in the water samples and spinach plant samples grown the mining area.

Materials and methods

Study area

Kolar Gold Fields (K.G.F.) was a principal gold mining centre in the country during late 19th and throughout 20th century. K.G.F. Urban Agglomeration, presently called as Robertsonpet Urban Agglomeration (RUA), is located in Bangarpet Taluk of Kolar district which is in southeastern part of Karnataka State in India. The area lies between 12°, 13' and 13°, 30' north latitude, and 78°, 10' and 78°, 20' east longitude. The study area has an altitude of 884 meters above mean sea level and covers an area of 58.12 sq.km. Robertsonpet area has an undulating hilly topography. Robertsonpet was essentially a gold mining township and the mining activity is more than a century old. According to 2001 census, the total population in the town of Robertsonpet Urban Agglomeration was 1,56,961. The decadal population growth was 0.14 percent. Density of population was 2,700 person per square kilometre. There is a slight increase in the sex ratio. The Sex ratio was 998 females per thousand males, and the total literacy rate was 89.36 percent. According to 2001 census, 24.39 percent people are categorized as 'main workers', 74.06 percent as 'non-workers', and the rest 1.53 percent 'marginal workers'. Mine workers migrated to this mining town as early as 1890s.

Sample collection method

Sample collection was done randomly from four different mining sites at KGF. 4 water samples were collected along with plants spinach (*Spinacia oleracea*) from the same agricultural land of Oorgaum, Tenants, Champion and Balghat areas which are 200, 100,100 and 400 meters away from gold mining sites respectively. These plants were collected in polyethylene bags. Plants were selected randomly and that were collected were partially submerged in water. Plants were rooted out from the soil. Soil samples were collected same sites. Samples were collected in two batches, one that was planted in the month of January and July 2020 respectively. Only 13 surface soils were collected and packed in polythene bags.

Sample treatment

Plants were separated into root, leaves and stem and were oven dehydrated at 110ºC. Soil samples were also oven dried at 110ºC. 4 grams of each sample was acid digested by nitric acid. Samples were kept on hot plate. After removing from hot plate, sample was sieved in 100 ml graduated cylinder up to 35 ml so that 35 ml of each sample was prepared. Water samples were directly subjected to analysis. Hardness of water samples was analyzed using flame photometer. Conductivity of water and soil samples was measured using conductivity meter while pH of water and soil samples was measured using pH meter (Black, Charles Allen; Methods of Soil Analysis 1973)

Sample analysis

Samples of plants and water were subjected to Thermo scientific make ICP-OES (Inductively Coupled Plasma-Optical Emission Spectroscopy) with Iteva software to analyze metals like As, Cd, Fe, Ni, Cr, Cu, Pb, and Mn. The instrument setting and operational conditions were done in accordance with the manufacturers' specifications.

Results and discussion

Physio-chemical parameters of water and soil.

Physical parameters include color of water and temperature whereas chemical considerations comprise alkalinity, dissolved oxygen contents, hardness, electrical conductivity, and pH,. In this experiment only chemical parameters such as hardness, electrical conductivity, and pH were measured. Table 1 shows the results for hardness, electrical conductivity, and pH of collected water samples. WHO normal range for hardness of water is 50- 250 mg/ml WHO [Ruqia Nazir et al 2015]. In all the collected water samples the mean concentration ranged above the permissible limits. The average hardness of all water samples was 239. WHO normal range for electrical conductivity of water is 400-600 µS/cm. In all the collected water samples values of electrical conductivity were recorded above the normal range with average being recorded as 1237 µS/cm, which is significantly high .WHO recommends normal ranges for pH of water between 6.5-8.5. pH of all the collected water samples collected in all the samples was recorded within the normal range.

Table 1: Chemical parameters of water samples

Water sample from the site	Hardness(ppm)	Electrical conductivity (μS/cm)	pH
Oorgaum (Sample 1)	280	1176	7.64
Tenants (Sample 2)	312	1218	7.22
Champion (Sample 3)	290	1489	8.28
Balghat (Sample 4)	345	1065	7.61

Table 2. Mean concentration of heavy metals (mg/L) in water samples.

Sample sites	Mean conc of as in mg/L ± S.D	Mean conc of Cd in mg/L ± S.D	Mean conc of Fe in mg/L ± S.D	Mean conc of Ni in mg/L ± S.D	Mean conc of Cr in mg/L ± S.D	Mean conc of Cu in mg/L ± S.D	Mean conc of Pb in mg/L ± S.D	Mean conc of Mn in mg/L ± S.D
Oorgaum	0.007 ± 0.023	0.014 ± 0.087	1.772 ± 0.087	0.06 ±0.397	1.271 ± 0.087	0.487 ± 0.087	0.271 ± 0.151	0.231 ± 0.147
Tenants	B.D.L	0.004 ± 0.029	2.028 ± 0.265	0.005 ± 0.397	2.886 ± 0.328	0.289 ± 0.005	0.321 ± 0.160	0.176 ± 0.283
Champion	0.005 ± 0.0017	0.165 ± 0.061	1.745 ± 0.13	0.001 ± 0.370	1.993 ± 0.16	0.596 ± 0.076	0.499 ± 0.269	0.343 ± 0.347
Balghat	0.008 ± 0.019	0.060 ± 0.145	2.443 ± 0.132	0.007 ± 0.191	1.889 ± 0.14	0.264 ± 0.024	0.176 ± 0.56	0.217 ± 0.148

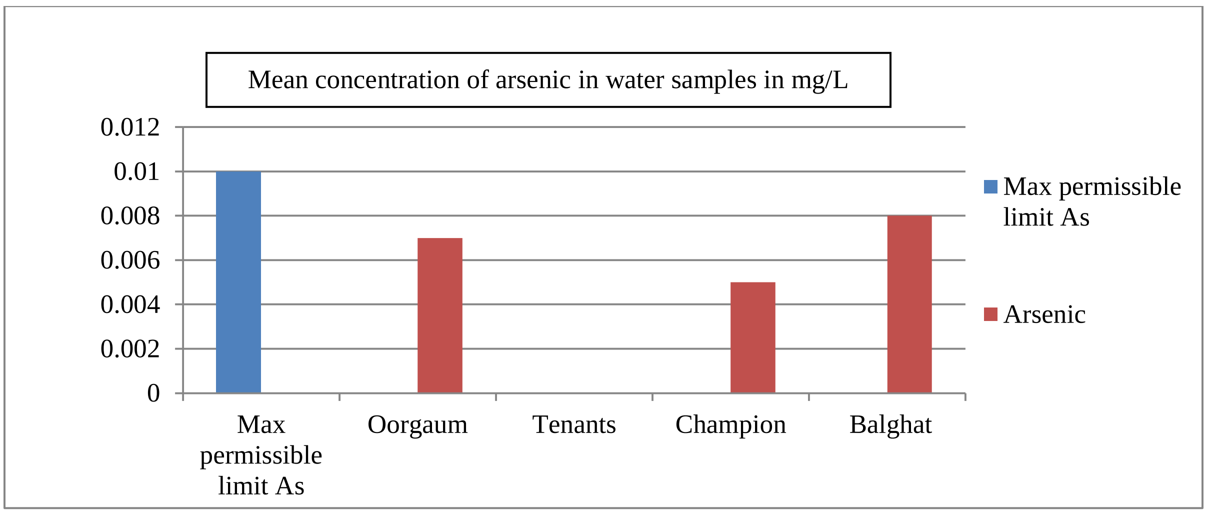

Fig 1: Mean concentration of arsenic (mg/L) in water samples.

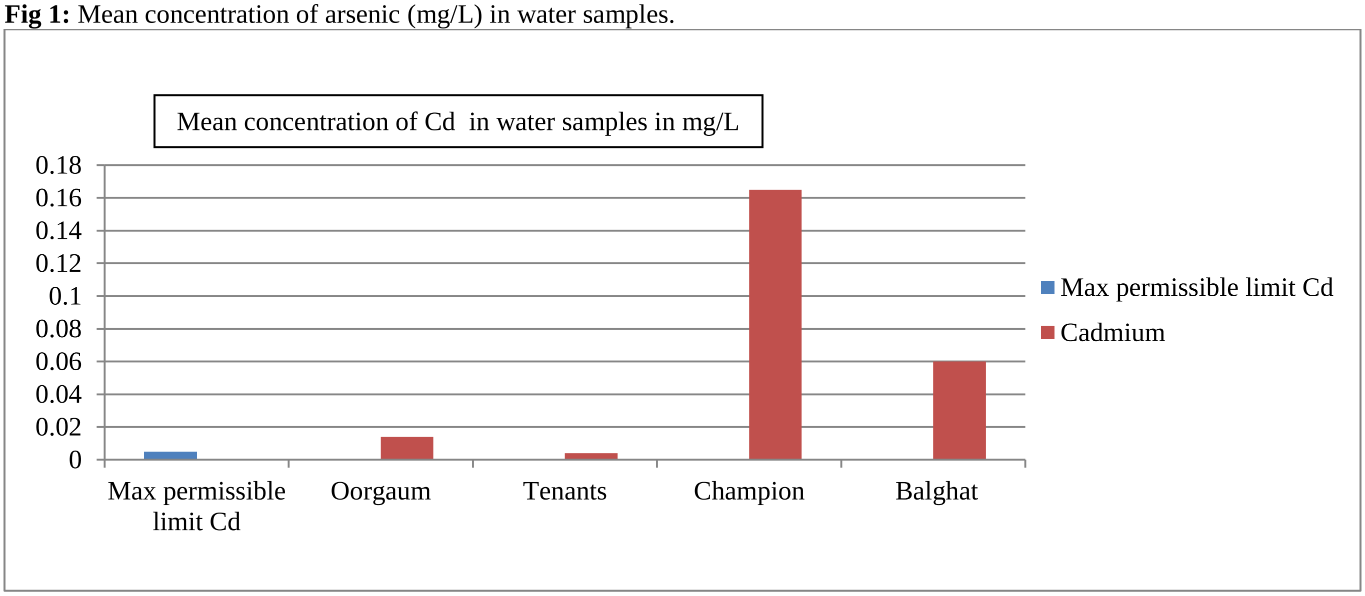

Fig 2: Mean concentration of cadmium (mg/L) in water samples.

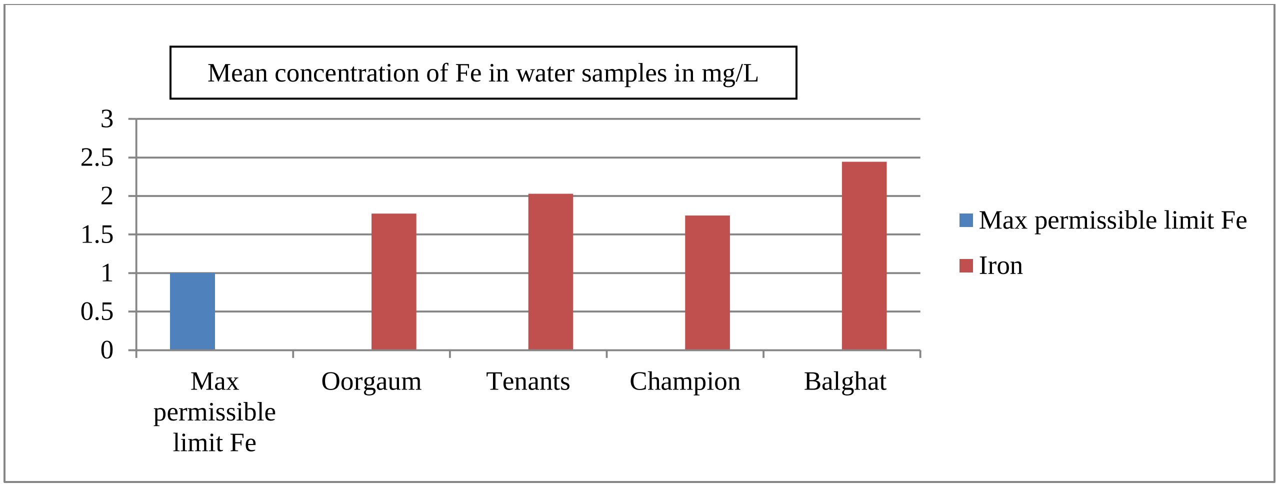

Fig 3: Mean concentration of Iron (mg/L) in water samples.

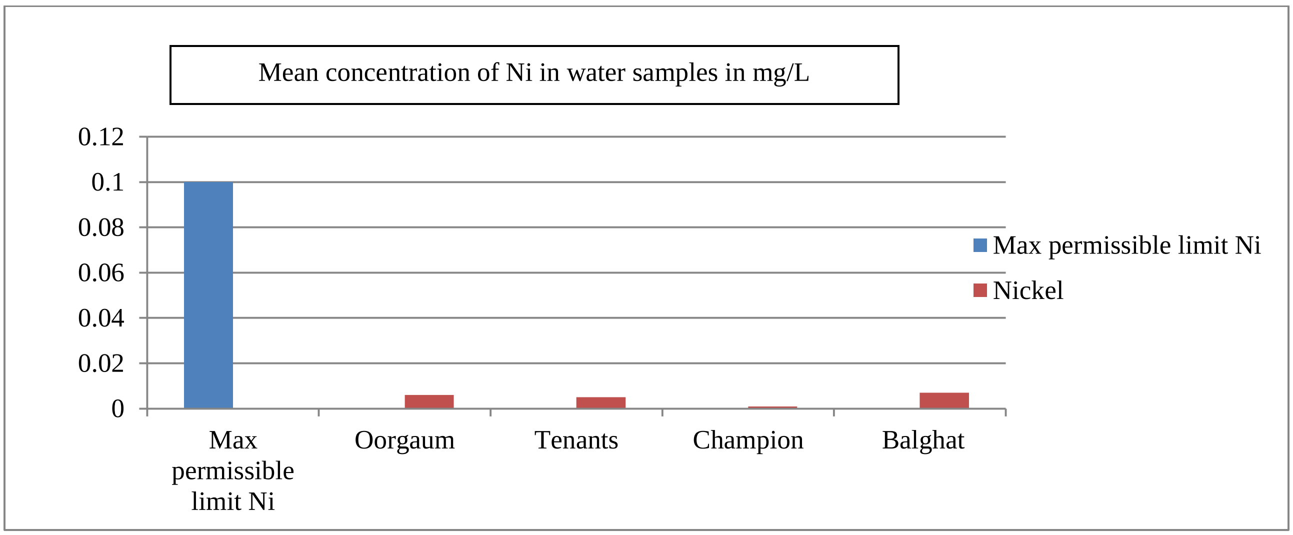

Fig 4: Mean concentration of nickel (mg/L) in water samples.

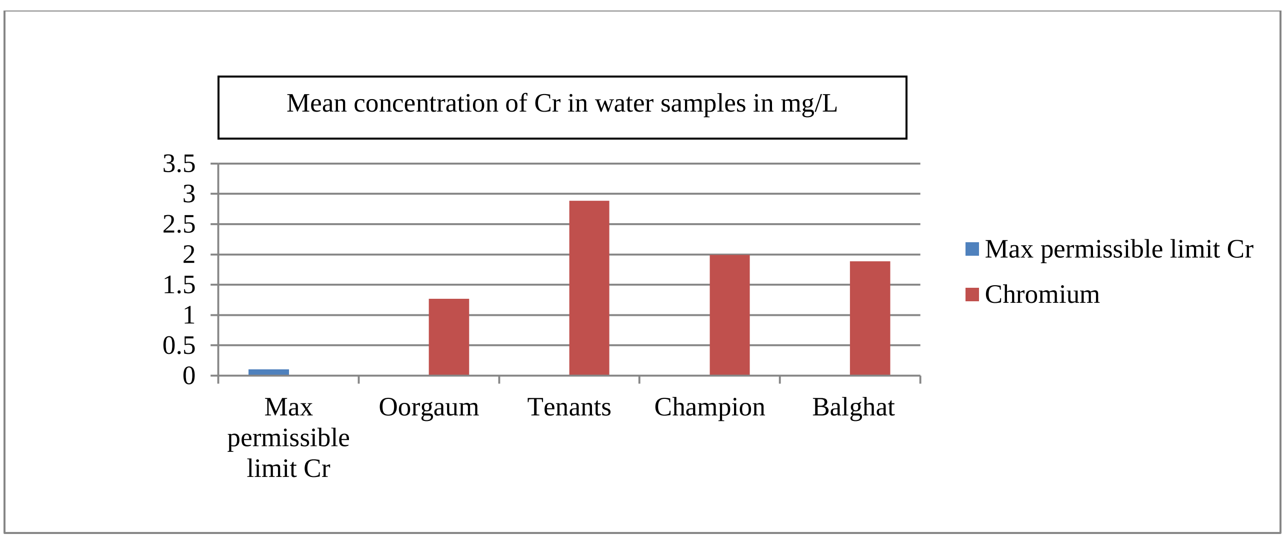

Fig 5: Mean concentration of chromium (mg/L) in water samples.

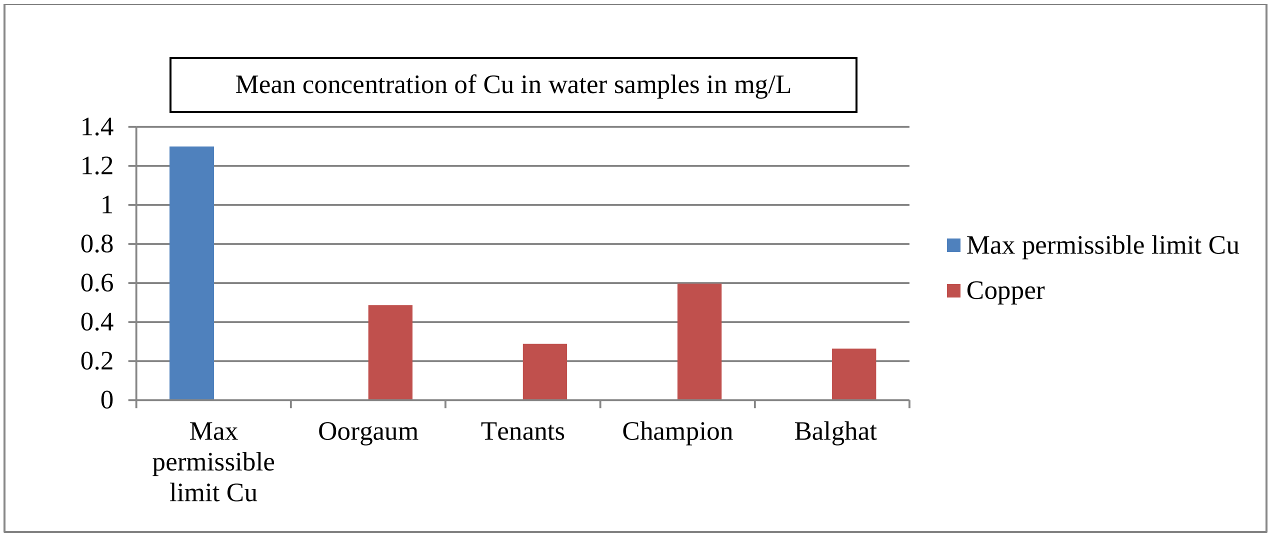

Fig 6: Mean concentration of copper (mg/L) in water samples.

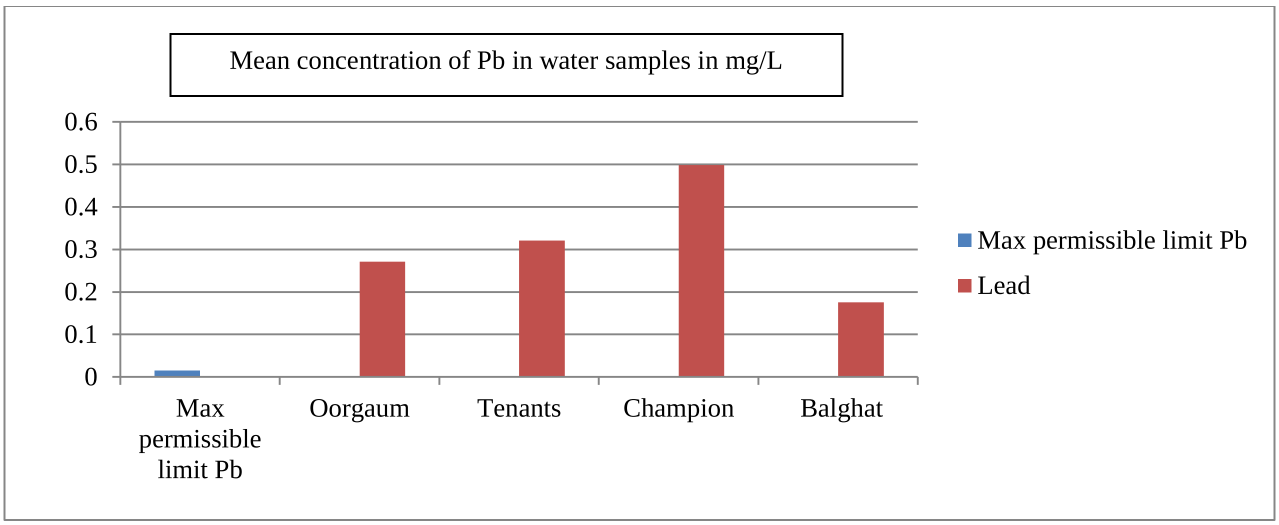

Fig 7: Mean concentration of lead (mg/L) in water samples.

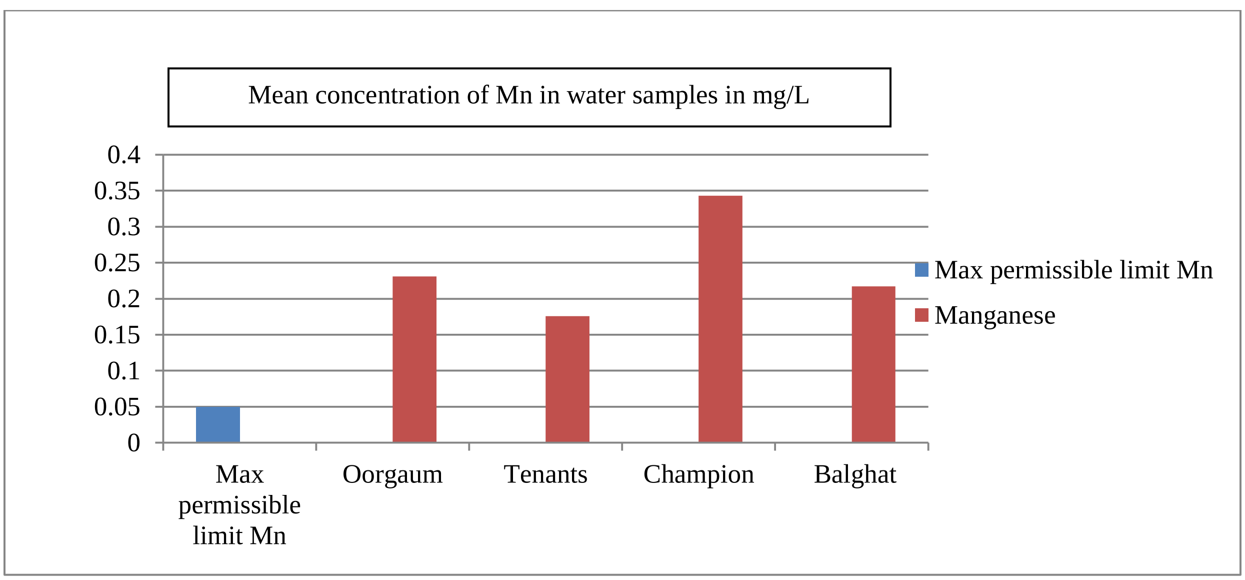

Fig 8: Mean concentration of manganese (mg/L) in water samples.

Likewise in all the collected soil samples pH was recorded within the normal range set by WHO while electrical conductivity was recorded above the permissible limits in Champion and Balghat for electrical conductivity set by WHO, whereas in Oorgaum and Tenants, the electrical conductivity of soil sample was within permissible limits.

Table 3: Chemical parameters of soil samples.

Soil sample from the site	Electrical conductivity (µS/cm)	pH
Oorgaum (Sample 1)	545	7.12
Tenants (Sample 2)	590	7.44
Champion (Sample 3)	780	7.05
Balghat (Sample 4)	810	6.86

Arsenic (As):

Arsenic is non-essential and toxic to plant growth, roots are the first tissue to get exposed to As, where the metalloid inhibits root extension and proliferation and damages cellular membranes (Singh et al., 2006). The maximum permissible limits of Arsenic in plants recommended by WHO is 1.0 mg/kg. The maximum permissible limit for As in water is 10 mg/l. Concentration of arsenic in water samples ranged between 0.005 to 0.008 mg/l which is below tolerable limit. In all the collected plant samples, arsenic was not found in either leaf or stem samples, but it was present in all 4 samples of root part of the plant the mean concentrations oscillated between 0.115 to 0.352 mg/kg which is less than permissible limits by WHO.

Arsenic (As) concentration (mg/kg) in the leaves, root and stem of *Spinacia oleracea* , S.D (Standard deviation), B.D.L (Below Detection Limit)

Table 4: Mean concentrations of arsenic in leaves, stem and root of *Spinacia oleracea* at various mining sites.

Region of the plant sample	Oorgaum (Mean concentration mg/kg ± S.D)	Tenants (Mean concentration mg/kg ± S.D)	Champion (Mean concentration mg/kg ± S.D)	Balghat (Mean concentration mg/kg ± S.D)
Leaves	B.D.L	B.D.L	B.D.L	B.D.L
Stem	B.D.L	B.D.L	B.D.L	B.D.L
Root	0.352 ± 0.037	0.117 ± 0.007	0.281 ± 0.021	0.115 ± 0.015

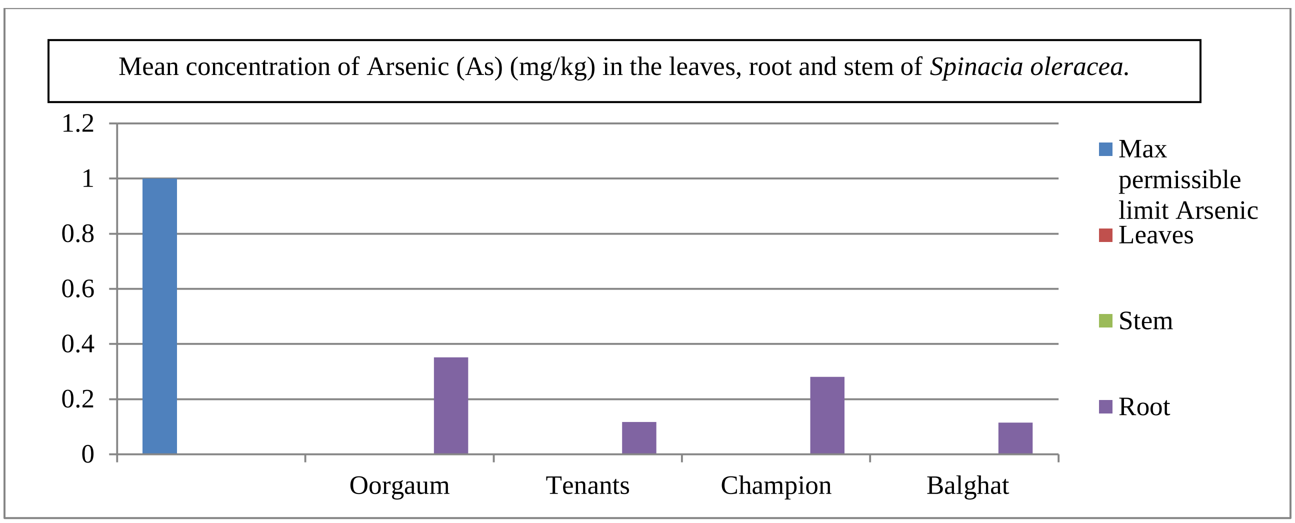

Fig 9: Mean concentration of Arsenic (As) (mg/kg) in the leaves, root and stem of *Spinacia oleracea.*

Cadmium (Cd):

The permissible limit of Cadmium in plants, suggested by WHO, is 0.02 mg/kg. In the plant *Spinacia oleracea* the mean concentration of cadmium was recorded between 0.066 to 0.352 mg/kg. The average concentration of a plant sample was within permissible limit in sample 4, whereas samples 1, 2 and 3 had higher range than suggested limits. The maximum permissible limit for Cd in water is 0.01 mg/l. Concentration of cadmium in water samples ranged between 0.004 to 0.165 mg/l. Water samples 3 and 4 recorded above permissible limit.

Cadmium (Cd) concentration (mg/kg) in the leaves, root and stem of *Spinacia oleracea* , S.D (Standard deviation), B.D.L (Below Detection Limit)

Table 5: Mean concentrations of cadmium in leaves, stem and root of *Spinacia oleracea* at various mining sites.

Region of the plant sample	Oorgaum (Mean concentration mg/kg ± S.D)	Tenants (Mean concentration mg/kg ± S.D)	Champion (Mean concentration mg/kg ± S.D)	Balghat (Mean concentration mg/kg ± S.D)
Leaves	0.217 ± 0.028	0.117 ± 0.0123	0.079 ± 0.008	B.D.L
Stem	0.352 ± 0.035	0.135 ± 0.031	0.086 ± 0.015	B.D.L
Root	0.328 ± 0.037	0.162 ± 0.013	0.088 ± 0.013	0.066 ± 0.004

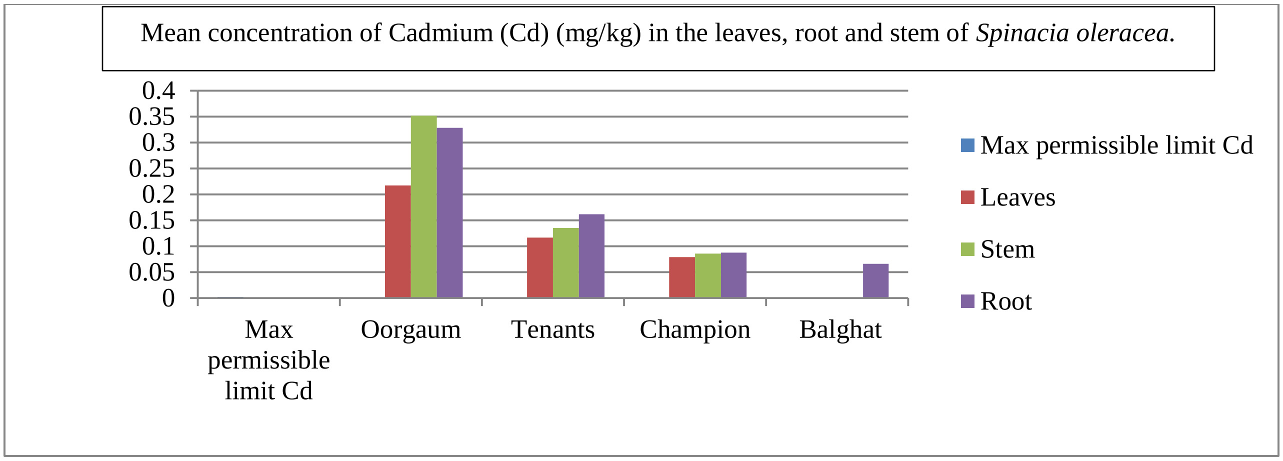

Fig 10: Mean concentration of cadmium (Cd) (mg/kg) in the leaves, root and stem of *Spinacia oleracea.*

Iron (Fe):

It comes into water from natural geological sources, engineering wastes, domestic release and also from byproducts. Iron in drinking water is present in ferrous or ferric state in suspended form. Excess amount of iron in water (more than 10 mg/kg) causes rapid escalation in pulse rate and coagulation of blood in blood vessels, and hypertension. The maximum allowed concentration of iron in drinking water is 1.0 mg/L according to WHO report [Gutam Patel et al 2011]. All 4 water samples, mean concentration showed significant amount of iron, which was higher than permissible limits. The WHO recommended level of iron in plants is 20 mg/kg [Afzal Shah et al 2011]. The leaves of *Spinacia oleracea* from sample site 1 showed higher range than permissible limit, whereas all other samples of various parts of the plant showed results within permissible limits recommended by WHO.

Iron (Fe) concentration (mg/kg) in the leaves, root and stem of *Spinacia oleracea*, S.D (Standard deviation), B.D.L (Below Detection Limit)

Table 6: Mean concentrations of iron in leaves stem and root of *Spinacia oleracea* at various mining sites.

Region of the plant sample	Oorgaum (Mean concentration mg/kg ± S.D)	Tenants (Mean concentration mg/kg ± S.D)	Champion (Mean concentration mg/kg ± S.D)	Balghat (Mean concentration mg/kg ± S.D)
Leaves	16.28 ± 0.006	18.45 ± 1.147	21.36 ± 4.66	15.42 ± 3.81
Stem	2.83 ± 0.004	2.83 ± 0.104	3.23 ± 0.107	2.32 ± 0.091
Root	7.35 ± 0.290	6.58 ± 0.423	5.89 ± 0.391	7.92 ± 0.241

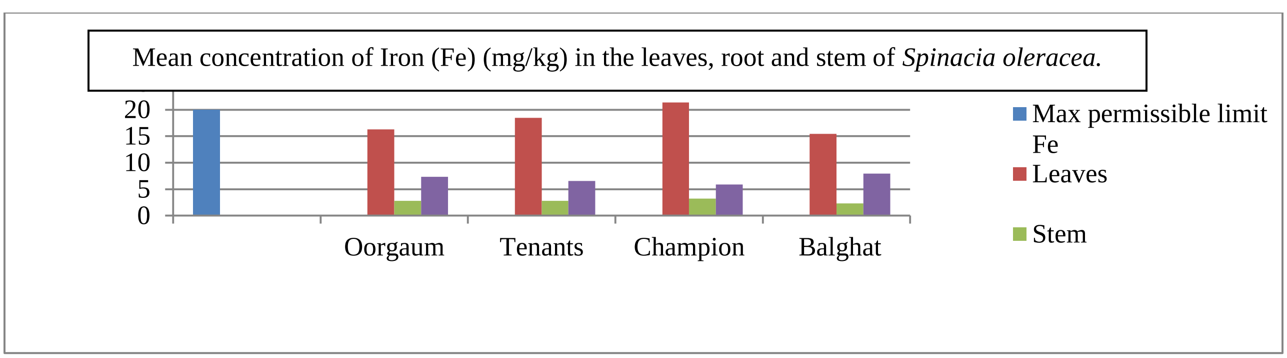

Fig 11: Mean concentrations of iron in leaves, stem and root of *Spinacia oleracea* at various mining sites.

Nickel (Ni):

Nickel (Ni): Nickel has been considered to be an vital trace element for human and animal health. [Zigham Hassan et al 2012].The permissible limit of Nickel in plants recommended by WHO is 10mg/kg. In all the collected plant samples there was no concentration of nickel found, except in the root part of sample 3. The maximum permissible limit for Ni in water is 0.2 mg/l Concentration of [Zigham Hassan et al 2012] nickel in water samples ranged between 0.001 to 0.007 mg/l, which was less than permissible limit as recommended by WHO.

Nickel (Ni) concentration (mg/kg) in the leaves, root and stem of *Spinacia.* , S.D (Standard deviation), B.D.L (Below Detection Limit)

Table 7: Mean concentrations of nickel in leaves stem and root of *Spinacia oleracea* at various mining sites.

Region of the plant sample	Oorgaum (Mean concentration mg/kg ± S.D)	Tenants (Mean concentration mg/kg ± S.D)	Champion (Mean concentration mg/kg ± S.D)	Balghat (Mean concentration mg/kg ± S.D)
Leaves	B.D.L	B.D.L	B.D.L	B.D.L
Stem	B.D.L	B.D.L	B.D.L	B.D.L
Root	1.495 ± 0.197	B.D.L	B.D.L	B.D.L

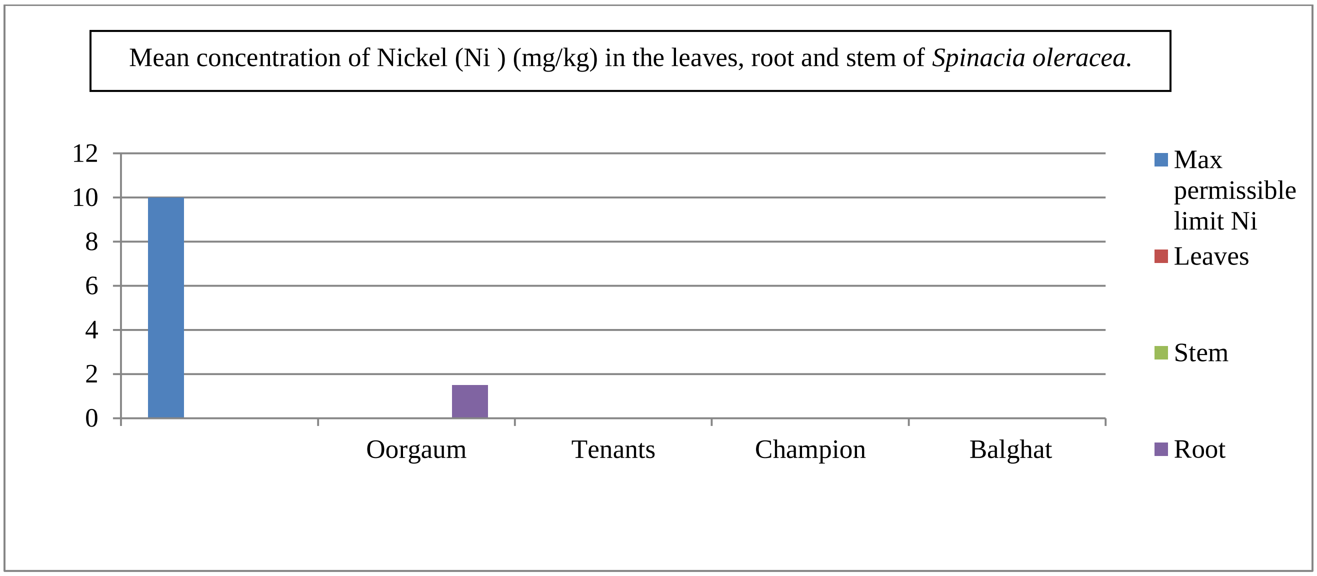

Fig 12: Mean concentrations of nickel in leaves, stem and root of *Spinacia oleracea* at various mining sites.

Chromium (Cr):

The maximum permissible limit for Cr in water is 0.1 mg/l. The mean values of Cr in all water samples ranged between 1.271 to 2.886 ml/l , which is above permissible limit, [Zigham Hassan et al 2012].In all the collected water samples concentration of chromium was recorded above the permissible limit set by WHO. The tolerable limit of Chromium for plants is 1.30mg/kg suggested by WHO. In plant *Spinacia oleracea.* The mean concentrations of chromium analyzed during two different time periods ranged between 0.288 to 2.46 mg/kg. The concentration of chromium was observed in leaves and roots of Tenants, Champion and Oorgaum, Balghat above permissible limits respectively. Stem samples of spinach plant had chromium concentrations within permissible limits.

Chromium (Cr) concentration (mg/kg) in the leaves, root and stem of *Spinacia oleracea* , S.D (Standard deviation), B.D.L (Below Detection Limit)

Table 8: Mean concentrations of chromium in leaves stem and root of *Spinacia oleracea* at various mining sites.

Region of the plant sample	Oorgaum (Mean concentration mg/kg ± S.D)	Tenants (Mean concentration mg/kg ± S.D)	Champion (Mean concentration mg/kg ± S.D)	Balghat (Mean concentration mg/kg ± S.D)
Leaves	1.231 ± 0.191	2.46 ± 0.235	1.812 ± 0.191	0.563 ± 0.175
Stem	1.23 ± 0.130	0.37 ± 0.204	0.288 ± 0.204	0.851 ± 0.391
Root	1.795 ± 0.197	0.85 ± 0.130	0.759 ± 0.130	1.87 ± 0.238

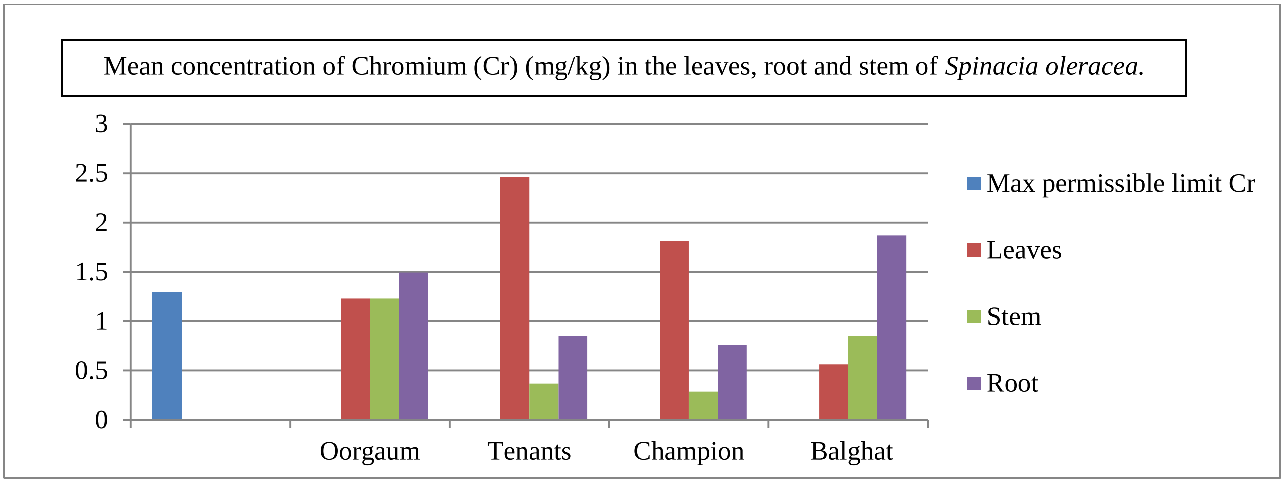

Fig 13: Mean concentrations of chromium in leaves, stem and root of *Spinacia oleracea* at various mining sites.

Copper (Cu):

The permissible limit of copper for plants is 10mg/kg recommended by WHO [Ruqia Nazir et al 2015].The mean concentrations of copper in plants during the months of January and July ranged between 0.429 to 3.48 mg/kg which was less than permissible limits. The highest average concentration of 2.647 mg/kg was found in leaves of the plant *Spinacia oleracea*. The maximum permissible limit for Cu in water is 2 mg/l in water samples mean concentration of copper ranged between 0.264 to 0.596 ml/l. In all the collected water samples the mean concentration was found contained within the permissible limits.

Copper (Cu) concentration (mg/kg) in the leaves, root and stem of *Spinacia oleracea* , S.D (Standard deviation), B.D.L (Below Detection Limit)

Table 9: Mean concentrations of copper in leaves, stem and root of *Spinacia oleracea* at various mining sites.

Region of the plant sample	Oorgaum (Mean concentration mg/kg ± S.D)	Tenants (Mean concentration mg/kg ± S.D)	Champion (Mean concentration mg/kg ± S.D)	Balghat (Mean concentration mg/kg ± S.D)
Leaves	1.231 ± 0.191	2.46 ± 0.235	1.812 ± 0.191	0.563 ± 0.175
Stem	1.23 ± 0.130	0.37 ± 0.204	0.288 ± 0.204	0.851 ± 0.391
Root	1.795 ± 0.197	0.85 ± 0.130	0.759 ± 0.130	1.87 ± 0.238

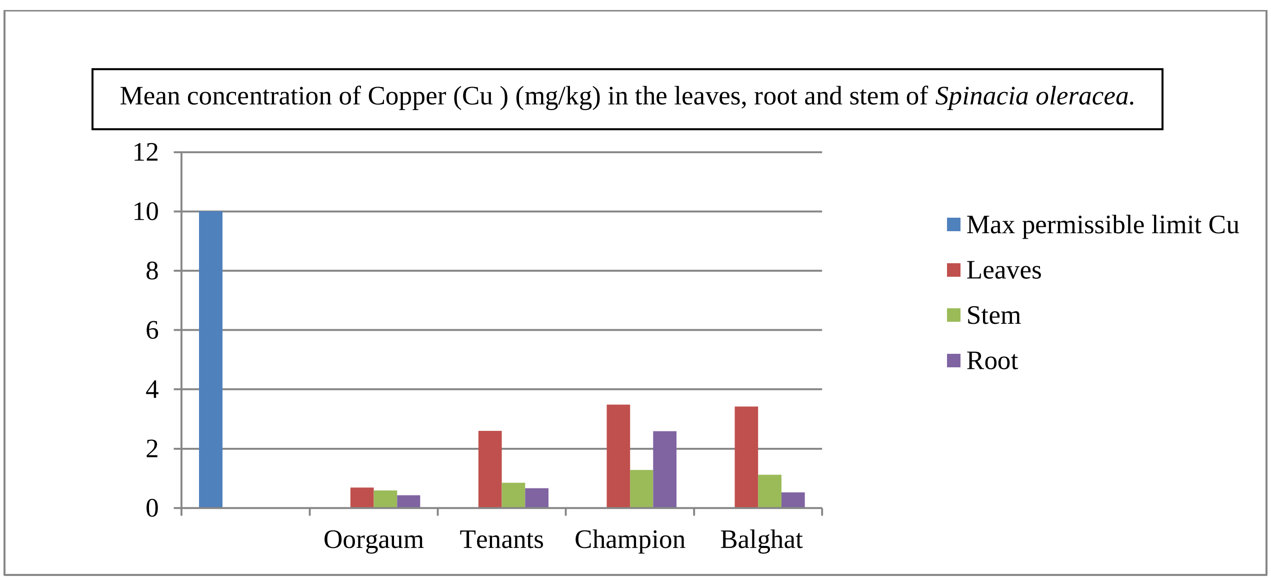

Fig 14: Mean concentrations of copper in leaves, stem and root of *Spinacia oleracea* at various mining sites.

Lead (Pb):

According to WHO standards permitted limit of lead in water is 0.05mg/l and in all the collected water samples mean concentration of lead was above the permissible limit. Concentration of lead in all the collected water samples ranged between 0.176 to 0.499 mg/l , which is above permissible limit. The permissible limit in plants recommended by WHO is 2mg/kg. In the leaves and stem part of plant samples, the concentration of lead was below detection level, whereas root samples of Champion and Balghat had above permissible limits recommended by WHO. The mean concentration of root samples ranged between 3.41 to 4.69 mg/kg.

Lead (Pb) concentration (mg/kg) in the leaves, root and stem of *Spinacia oleracea* , S.D (Standard deviation), B.D.L (Below Detection Limit)

Table 10: Mean concentrations of lead in leaves, stem and root of *Spinacia oleracea* at various mining sites.

Region of the plant sample	Oorgaum (Mean concentration mg/kg ± S.D)	Tenants (Mean concentration mg/kg ± S.D)	Champion (Mean concentration mg/kg ± S.D)	Balghat (Mean concentration mg/kg ± S.D)
Leaves	B.D.L	B.D.L	B.D.L	B.D.L
Stem	B.D.L	B.D.L	B.D.L	B.D.L
Root	B.D.L	B.D.L	3.41 ± 0.16	4.69 ± 0.18

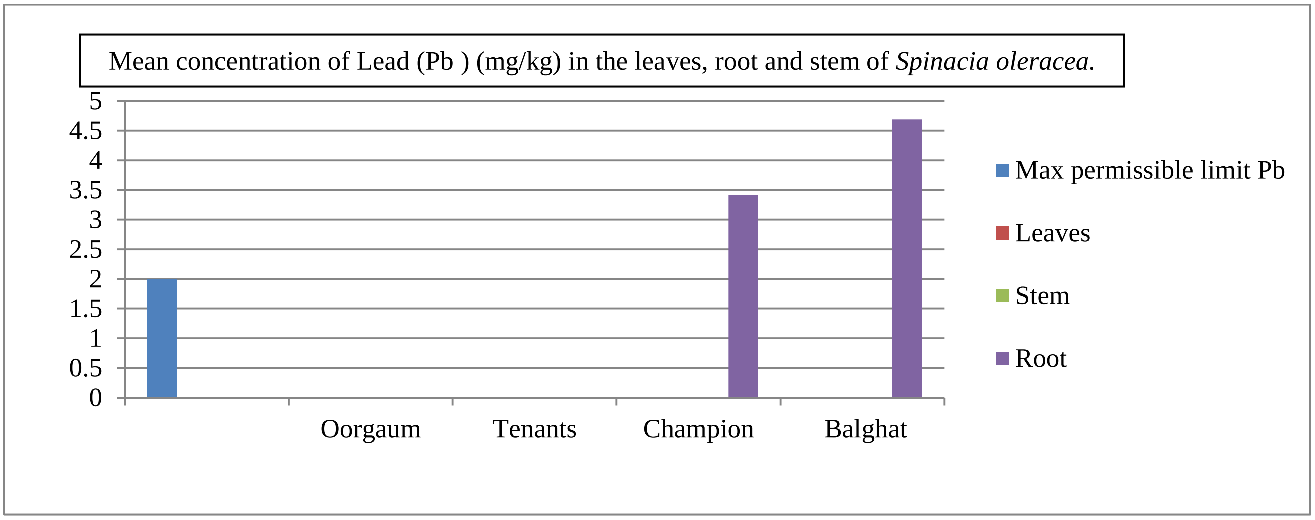

Fig 15: Mean concentrations of lead in leaves stem and root of *Spinacia oleracea* at various mining sites.

Manganese (Mn):

The maximum permissible limit for Mn in water is 0.20 mg/l. The mean values of Mn in all water samples ranged between 0.176 to 0.343 mg/l. The mean concentrations of water samples collected from Oorgaum and Balghat showed significant values, which were above permissible limits. The permissible limit in plants recommended by WHO is 6.61 mg/kg. The average concentrations of Mn in all plant samples ranged between 1.09 to 7.1 mg/kg. The concentration of Mn was not found in significant range in most of the samples except, the root part of Balghat sample which had above permissible limit of 7.1 mg/kg. The average concentrations of leaves stem in plant *Spinacia oleracea* in all the collected samples was 2.232 and 1.517 mg/kg respectively, which was within the permissible limits of WHO.

Manganese (Mn) concentration (mg/kg) in the leaves, root and stem of *Spinacia oleracea* , S.D (Standard deviation), B.D.L (Below Detection Limit)

Table 11: Mean concentrations of manganese in leaves, stem and root of *Spinacia oleracea* at various mining sites.

Region of the plant sample	Oorgaum (Mean concentration mg/kg ± S.D)	Tenants (Mean concentration mg/kg ± S.D)	Champion (Mean concentration mg/kg ± S.D)	Balghat (Mean concentration mg/kg ± S.D)
Leaves	1.32 ± 0.128	2.81 ± 0.030	2.35 ± 0.029	2.45 ± 0.029
Stem	1.17 ± 0.15	1.17 ± 0.037	1.82 ± 0.017	1.91 ± 0.017
Root	1.81 ± 0.123	1.97 ± 0.121	1.09 ± 0.023	7.1 ± 0.029

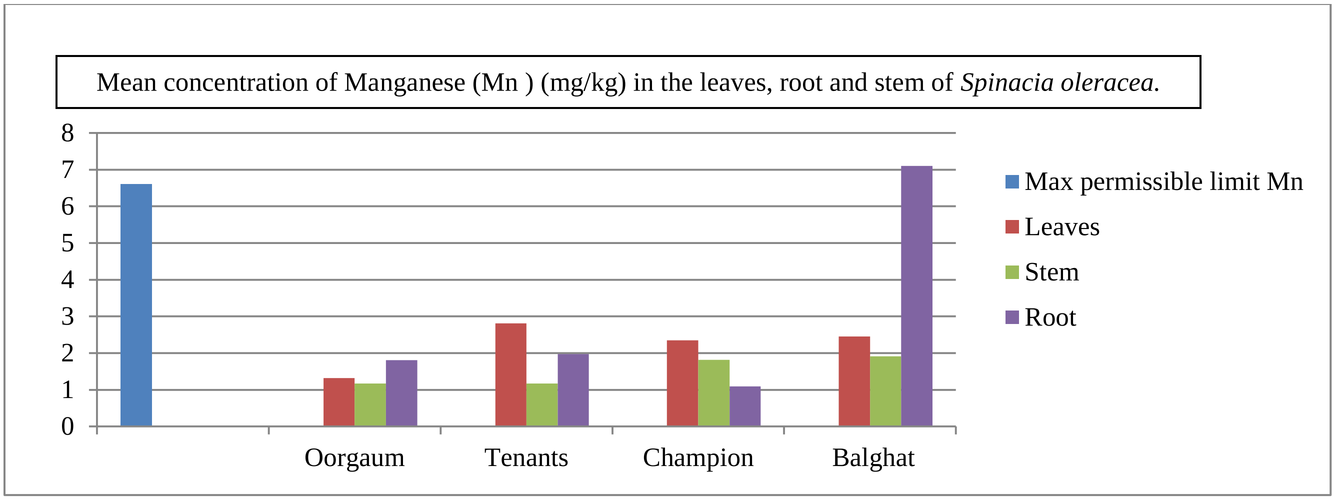

Fig 16: Mean concentrations of manganese in leaves, stem and root of *Spinacia oleracea* at various mining sites.

Discussion

Existing study was conducted in order to evaluate the heavy metal pollution of water and plants of *Spinacia oleracea* various mining sites at Kolar Gold Fields (K.G.F), Karnataka, India. As water contamination is treacherous for both aquatic and human wellbeing so it is the essential to gauge the water quality of ground water and ponds as this is a very significant issue correlated to human and environment. For this purpose ground water and soil samples from four different mining sites which were located near residential and agricultural lands were collected. Water and soil samples were subjected for physio-chemical properties and presence heavy metals were studied in water samples. Plants were only analyzed for heavy metals. Results were presented in the form of tables.

When water samples were collected and examined for heavy metals (As, Cd, Fe, Ni , Cu Ni, Pb and Mn) it was found that the concentrations of heavy metals i.e. cadmium, iron, chromium, lead and manganese were beyond the maximum permissible limits set by USEPA. The study revealed the heavy metal content in the water of mining sites is beyond the normal range and is extremely dangerous for agricultural usage. Analysis of chemical parameters of water concluded that pH of water is within the normal range set by WHO while electrical conductivity and hardness of water were recorded above the normal range set by WHO. pH of all soil samples was recorded below the normal range while electrical conductivity of all soil samples was recorded above the normal range. In the plant *Spinacia oleracea***,** the mean concentration of arsenic was found within the permissible limits, whereas in the leaves and stem part of the plant the concentration of arsenic was below detection limit. The mean concentration of cadmium was above permissible limits in the plant sample leaves, stem and roots collected from sample 1 (Oorgaum) and sample 3 (Champion). The mean concentration of iron was found within range recommended by WHO in plant samples collected from all four samples sites. The nickel was not found in any of the plant sample collected from all four sites, except in root part of sample 1 (Oorgaum) which was within permissible limit of WHO. The mean concentration of chromium was found above permissible limits in leaves of sample 2 and 3 (Tenants, Champion) and in roots of sample 1 and 4 (Oorgaum , Balghat), whereas the stem part of all 4 samples contained permissible limits of chromium in it. The mean concentrations of copper in plant samples collected from 4 mining sites showed normal range recommended by WHO. The mean concentration of lead was above permissible limits in the root part of sample 3 and 4 (Champion and Balghat), whereas the leaves and stem part of plant *Spinacia oleracea* showed values within range in all 4 sample sites. The mean concentration of lead was above permissible limits in the roots of the plant *Spinacia oleracea* collected from samples 3 and 4 (Champion, Balghat), lead was not found in leaves, stem and root of sample 1 and 2 (Oorgaum, Tenants). The mean concentration of manganese was found below permissible limit in the leaves and stem of all 4 samples, except the root of the plant *Spinacia oleracea* collected from sample 4 (Balghat) which showed above permissible limit as recommended by WHO.

The cause for this extremity in values is due to the existing gold mill tailings dumped from past 150 years. The gold mill tailings consist of various heavy and non-heavy metals in soil, which directly gets percolated into ground water and ponds during rainy season. This is in turn deteriorates the water quality making it unsuitable for agriculture and human consumption.

Conclusion and Recommendations

The focal goal of this study work was to gauge the concentration of some toxic heavy metals in crops and also some chemical parameters such as pH, electrical conductivity and hardness of water and soil collected from Kolar Gold Fields mining sites. A total of 4 water samples were collected during the month of January and July and mean concentrations were analyzed for the presence of heavy metals and three chemical parameters (hardness, electrical conductivity and pH) two chemical parameters of soil (electrical conductivity and pH) two chemical parameters (pH and EC) were analyzed. Eight heavy metals (As, Cd, Fe, Ni, Cr, Cu, Pb and Mn) while a major plant *Spinacia oleracea* commonly known as spinach is grown which was also analyzed during these two seasons for the presence of eight heavy metals (As, Cd, Fe, Ni, Cr, Cu, Pb and Mn) using standard protocols. The results show that in the plant sample the leaf had heavy metals like Cd, Fe and Cr above permissible limit as recommended by WHO. Stem part of the plant sample contained Cd and in root sample, heavy metals like Cd, Cr, Pb and Mn were found above permissible limits. Therefore it is suggested that the crops grown in these surroundings should be assessed for the presence of heavy metals and water quality has to be checked before using it for agricultural purpose.

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