SUMMARY
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Metal contamination in water and soil is a worldwide growing issue especially in developing countries. Many wild plants have ability to survive in metal rich environment.

Researchers are trying to find out tolerant wild species so that the isolated tolerance gene can be inserted in economically important plants. The genetic engineering procedure will unlock many ways for production of efficiently key plants in barren land and metal rich soil.

Study of metal stress is a prominent research area in the field of physiology and molecular biology.

Present study is carried out to evaluate physicochemical characteristics of water and soil reside in barren land near khetri copper mine. Barren land can provide most promising and accurate results as it is least effected by any anthropological factor.

Whole study area is limited to 200 meter from copper mine. The samples of water, soil and plants were collected from 10 different locations to cover all possible variation of metal concentration in plant environment.

The location was decided on the basis of decreasing distance from core area as sample A is located in remote area and sample J is collected from nearest about 10 meter distance from mine. Mine drainage, metal waste and pipelines to mine were included in study sites.

Physicochemical Properties of Water available to plants grown near Copper Mine

Water samples were analyzed with standard methods for limited most significant physicochemical properties. Parameters such as water pH, total hardness, electrical conductivity, metal contaminants viz. Cu, Zn and Cd were analysed to evaluate effect of mining on physicochemical properties of water.

Results of water analysis indicates lowering of water pH, total hardness and rising electrical conductance with decreasing distance from copper mine. The pH values of water was 7.9, 7.6, 8.9, 8.8, 7.5, 8.5, 8.8, 8.6, 7.4 and 5.8 in sample A, B, C, D, E, F, G, H, I, and J, respectively.
The electrical conductance was also 4.8, 6.9, 12.8, 16.4, 4.4, 17.2, 16.9, 16.8, 4.4 and 3.6 folds higher than standard water in water C. Similarly, 0.72, 0.76, 1.01, 2.0, 1.13, 2.03, 1.72 and 1.05 fold higher values of total hardness was also reported from sample A, B, C, D, E, F, G, H, I, and J, respectively. About 21, 18.6, 17.5, 19.2, 19.9, 26.06, 21.8, 28.13, 44.7 and 76.8 times higher than normal permissible limit of copper concentration was recorded in test samples A, B, C, D, E, F, G, H, I and J, respectively.

The amount of zinc reported was 2.4, 3, 2, 2, 3.1, 2.4, 2.6, 2.68, 3.4 and 3.56 folds higher than minimum acceptable limit of zinc concentration in water in sample site A, B, C, D, E, F, G, H, I, and J respectively. Alternation in cadmium concentration was a matter of concern as about 280, 290, 180, 150, 200, 180, 140, 160, 320 and 370 folds higher than tolerable limit cadmium concentration was reported in A, B, C, D, E, F, G, H, I, and J respectively.

The concentration of copper, zinc and cadmium was also analyzed in water sample. The results show the metal concentration was comparatively many folds higher in samples collected from wild location than previous reports from locality near Khetri copper mine. The increased amount of metal component may be a result of drainage water, air and edaphic contribution from mining activities. Therefore, the findings were more significant as chances of modifications by purification or remedial procedures are about nil.

**Physicochemical Properties of Soil available to plants grown near Copper Mine**

Another environmental factor directly affects the survival of plant species is soil near mine. The soil samples were also collected from rhizosphere of most abundantly distributed plants. Standard methods were used for sample collection and evaluation of most important properties of soil exist in wild area near copper mine. It has been reported that acidic soil is present in closest distance from mine. Electrical conductance was also high in soil samples. Similarly metal concentration was also very high in wild sample in comparison to previously reported properties of soil samples studied from populated area near copper mine. The high metal concentration in soil was anticipated and supported by analysis.
It was found that copper, zinc and cadmium concentration was very high in wild area near khetri mine. The colour and texture of soil also supported the findings as soil color was appeared as grey- black and yellow black. The appearance of soil also indicates high metal contamination. Multifold copper, cadmium and zinc concentration was reported in soil samples collected in the present study. A correlation was also calculated between abundance of plant species and metal concentration of soil in each study area. Although, the soil metal concentration was generally higher than permissible limit in all study points but a significant correlation between soil metal concentration and abundance of plant concluded that only a limited number of plant species are able to survive with high concentration of metal in soil and water.

The soil was highly alkaline in outlying area but acidic nature of soil was increased with decreasing distance from mine. The pH of various study sites were recorded as 7.4, 7.6, 7.7, 7.6, 6, 7.7, 7, 6, 5.2, 4.7 in water samples of study site A, B, C, D, E, F, G, H, I and J, respectively.

Another physicochemical parameter alters and about 8.848, 5.216, 16.884, 12.488, 5.824, 13.468, 18.248, 12.832, 4.928 and 4.8 folds higher than normal electrical conductance was reported in soil samples of study site A, B, C, D, E, F, G, H, I and J, respectively.

Moreover, total hardness of soil solution the pattern shows that soil samples from far-off sites have high total hardness where as hardness was reduced with increasing vicinity to mine. The maximum permissible limit about three, four, nine, eleven, fifteen, thirteen, twelve, sixteen, twenty two and forty three times higher copper concentration was recorded in sample A, B, C, D, E, F, G, H and I, respectively.

Zn is an essential element for plants but amount of Zn higher than normal value was reported in each study site. About 1.16, 6.2, 7.1, 8.4, 9.85, 8.24, 9.56, 10.23, 13.5 and 14.78 folds higher than standard limit zinc concentration in soil was noticed in soil samples A, B, C, D, E, F, G, H, I and J.

Cadmium is considered as toxic substance to plants but Cd contamination has been reported by various researchers. About 70, 195, 440, 570, 900, 635, 675, 935, 1160 and 1425 times higher than regular cadmium concentration was observed in soil.
sample samples A, B, C, D, E, F, G, H, I and J. The results concludes that soil in wild zone near copper mine is highly contaminates with toxic metal concentrations. Even though conditions are harsh and environment is somewhat unfavorable to survive but many plant species have tolerance mechanisms to combat with metal stress.

**Analysis of plants grown near copper mine**

Collection and morphological analysis of vegetation survive near copper mine results in a list of plant species. Morphological study of about one hundred twenty six plant species shows that root, plant hight and structure of plant body in affected by high metal concentration. 

*Abutilon fruticosa, Abutilon indicum, Acacia nilotica, Acacia Senegal, Achyranthus aspera, Adhatoda vasica, Adiantum venustum, Aerva persica, Ageratum conyzoides, Albezia lebbeck, Aloe vera, Alysicarpus vaginali, Amaranthus spinosus, Anogeissus pendula, Argemone Mexicana, Aristida adsansonis, Aristolochia bracteolata, Asparagus racemosus, Asphodelus tenuifolius, Azadirachta indica, Balanites aegyptica, Barleria prionitis, Blepharis sindica, Blumea oblique, Boerhavia diffusa, Boswellia serrata, Butea monosperma, Caesalpinia pulchirrima, Calligonum polygonoides, Calotropis procera, Capparis decidua, Cassia acutifolia, Cassia angustifolia, Cassia fistula, Chenopodium album, Citrullus colocynthis, Cleome gynandra, Clerodendrum indicum, Coccinia indica, Cocculus pendulus, Commiphora munia, Convolvulus arvensis, Convolvulus microphyllus, Corchorus depressus, Cordia gharaf, Corollocarpus epigous, Cressa cretica, Crotalaria burhia, Crotalaria medicaginea, Cuscuta chinensis, Cuscuta hyaline, Cymbopogon flexuosus, Cyondon dactylon, Cyperus rotundus, Dalbergia sisso, Datura metel, Decytotenum aegypticum, Dicomo tomentosa, Digera muricata, Echinops echinatus, Eclipta prostrate, Euphorbia caducifolia, Fagonia cretica, Ficus bengalensis, Ficus religiosa, Fimbristylis quinquiraris, Ganoderma lucidum, Glinus lotoides, Glossnema varians, Grewia villosa, Imperata cylindrical, Indigofera oblongifolia, Ipomoea hederaceae, Kapok bush, Launaea residifolia, Leucas aspera, ...
Leucas urticaefolia, Lindenbergia indica, Lycium barbatum, Malva rotundifolia, Mangifera indica, Maytenus emeriginat, Mimosa hamata, Mollugo cerviana, Momordica balsaminia, Momordica dioica, Morinda oleifera, Ocimum americanum, Opuntia elator, Panicum antidotale, Parthenium hysterophorus, Pentatropis spiralis, Peristrophe bivalvis, Phoenix acaulis, Phoralea corylifolia, Polycarpacea corymbosa, Polygala chinensis, Polygonum plebium, Portulaca oleracea, Prosopis cineraria, Psoralea odorata, Pulicaria crispa, Rhus coriara, Rhus mysorensies, Rivea ornata, Salvadoria oleoides, Saraca asoca, Sehima nervasum, Sida acuta, Sida alba, Solanum albicule, Solanum nigrum, Solanum surrattense, Surcostemma acidum, Tamarindus indica, Tecomella undulata, Tephrosia villosa, Tinospora cordifolia, Tribulus alatus, Vernonia anthelmintica, Vernonia cinerea, Viola cinerea, Withana somnifera and Zizyphus nummulariawe were major plant species observed near copper mine.

Five plant species were screened out showing tolerance and specific morphological adaptation traits. In common a small, dense and light green in colored plants were appear in metal rich soil. Some plants are noticed in outer most zones only but completely vanished in next area under research. These species are considered as sensitive plant species. Five plant shows sensitivity towards increasing metal concentration. Raunkiaer’s frequency class percent distributions in total vegetation present near mine area was calculated to understand the pattern of distribution of total plant species. It was observed that Frequency Class A (1-20%), B (21-40%), C (41-60%), D (61-80%), E (81-100%) contains 3.96%, 11.11%, 36.50%, 23.15% and 25.39% plant species of total reported plant species.

Three among five tolerant plant species viz. Adhatoda vasica, Aerva persica, Chenopodium album, Cressa cretica and pulicaria crispa were maintained constant appearance with changing soil and water properties. Sensetive plant species viz. Pentatropis spiralis, Cassia angustifolia, Datura metel, Vernonia cinerea and Solanum nigrum were limited upto far most sample sites only. Above mention plant species contains 340.5, 111.0, 630.4, 118.0 and 330.2 mg Cu mg / kg dry weight of plant tissue, respectivly. The cadmium concentration in was 0.671, 1.011, 0.722, 0.873
and 4.732mg Cd/ Kg dry weight of plant tissues in *Pentatropis spiralus, Cassia angustifolia, Datura metel, Vernonia cinerea and Solanum nigrum* respectively. Similarly zinc concentration 82.5, 166.0, 158.0, 172.4 and 152.5mg Zn/Kg dry weight of plant tissues was recorded in *Pentatropis spiralus, Cassia angustifolia, Datura metel, Vernonia cinerea and Solanum nigrum*, respectively.

Whereas Tolerant plant species such as *Adhatoda vasica, Chenopodium album, Cressa cretica, Pulicaria crispa* and *Aerva persica* have 178.7, 231.1, 530.2, 78.30, 389.3mg Cu/ Kg dry weight of plant tissues. The cadmium concentration recorded in tolerant plant species was 0.0.82, 0.672,1.055, 2.012, 0.082 mg Cd/ Kg dry weight of plant tissues. Soil and water near copper mine is also rich in Zn concentration therefore tolerant plant species *Adhatoda vasica, Chenopodium album, Cressa cretica, Pulicaria crispa* and *Aerva persica* have Zn depositions 184.0, 196.0, 158.2, 244.7 and 95.5 mg Zn/Kg dry weight of plant tissues. The concentration of metal viz. copper, cadmium and zinc are analyzed and a very high amount of metals indicates the callous inner conditions of plants survive near metal mine.

**Significance of the study**

The outcome of present study develops a comprehensive image of metal stress in soil and water in wild area near copper mine. Further the morphological analysis of metal tolerant and metal sensitive wild plant species also indicates towards potential gene pool that could be used for improvement of crop variety.