Effect of Soil Contamination on Some Heavy Metals Content of *Cannabis sativa*

[1,2]MURAD ALI KHAN*, [2]ABDUL WAJID, [2]SUHAIL NOOR, [2]FAREEDULLAH KHAN KHATTAK, [2]SAEED AKHTER AND [2]INAYAT UR RAHMAN

[1]*Department of Chemistry, Kohat University of Science and Technology, Kohat, Pakistan.*

[2]*PCSIR Laboratories Complex, Peshawar, Pakistan.*

(Received 7th January 2008, accepted in revised form 10th June 2008)

Summary: Heavy metals were investigated in the medicinal plant *Cannabis sativa* and the soil of the area from where the plant was collected using atomic absorption spectrophotometer. The plant samples were collected from five different locations of N.W.F.P, Pakistan. The plant parts including roots, stem and leaves were found to have the quantity of heavy metals corresponding to their contents in the soil. The purpose of the study is to make awareness among the people about the proper use and collection of medicinal plants, containing high level of heavy metals and their adverse health effects.

Introduction

The increasing level of pollution poses a serious threat to the environment all over the globe. The major pollutants that pose a risk to the ecological system are the different types of oxides and the toxic trace metals like lead, cadmium, manganese, copper, chromium cobalt etc.

Accumulation of metals in plants is highly dependent on their availability in soil, defined as a dynamic three-step process involving, physico-chemically, physiologically and a toxic dynamic process within body [1]. The unscientific use of hazardous materials in agriculture and industries and its dumping has created a great risk for human life, plant and animals. Similarly the heavy metals are assimilated in the environment from vehicle exhaust, from the smoke of industries or the spreading of industrial effluents through water in soil.

The use of herbal medicines is on the rise in recent years due to their low prices and unawareness about their side effects. There is common concept among the people that herbal medicines have no side effects and that "being natural in origin, herbs are safe". Heavy metals have great tendency to accumulate in human organs over prolonged periods of time. The presence of heavy metals beyond the permissible limits can cause metabolic disturbances. Thus both the deficiency and excess of essential micronutrients such as Fe, Zn and Cu may be harmful to the human health [2]. Effects of toxic metals (Cd, Cr, Pb, Ni etc.) on human health and their interaction with essential trace elements may produce serious consequences [3]. World Health Organization (WHO) recommends that medicinal plants which form the raw materials for the finished products may be checked for the presence of heavy metals, pesticides, bacterial or fungal contamination [4]. Environmental impact of heavy metals such as Cd, Pb, Hg and As, as well as their health effects has been the source of major concern [5-7].

Cannabis sativa Linn. (family: Cannabinaceae) is a reputed narcotic source and is used as a source of many type of narcotic drugs. It is widely distributed in Western and Central Asia like India, Pakistan, Sri Lanka and China [8]. It is an annual herb, usually erect; stems variable, up to 5 m tall [9, 10].

Medicinal uses of Cannabis sativa

Cannabis sativa Linn. has wide medicinal uses, the plant is used as tonic, intoxicant, stomachic, antispasmodic, analgesic, narcotic, sedative and anodyne in old Chinese medicines [11]. The seed, either as a paste or as an unguent, is said to be a folk remedy for tumors and cancerous ulcers. The decoction of the root is a remedy for hard tumors and knots in the joints. The leaves, prepared in various manners, is said to alleviate cancerous sores, scirrhous tumors, cold tumors, and white tumors. The plant is also used for mammary tumors and corns. Europeans are said to use the drugs from *Cannabis* pipes in "cancer cures". Seeds ground and mixed with porridge given to weaning children [12].

*To whom all correspondence should be addressed.

Cannabis sativa is a multiple-use plant, furnishing fiber, oil, medicine, and narcotics. Fibers are best produced from male plants. In the temperate zone, oil is produced from females, which have been left to stand after the fiber-producing males have been harvested. Leaves are added to soups in South East Asia. Varnish is made from the pressed seeds. Three types of narcotics are produced: hashish (bhang), the dried leaves and flowers of male and female shoots; ganja, dried unfertilized inflorescences of special female plants; and charas, the crude resin, which is probably the strongest. Modern medicine uses cannabis in glaucoma and alleviating the pains of cancer and chemotherapy. More resin is produced in tropical than in temperate climates. Lewis lung adenocarcinonoma growth has been retarded by oral administration of delta-9-tetrahydrocannabinol, delta-8-tetrahydrocannabinol and cannabinol, but not by cannabidiol. The delta-9 also inhibits the replication of Herpes simplex virus [9, 10].

Results and Discussion

Metal uptake by plants is reported to be governed by a combination of metal species in solution, labile sorbed to dissolved components, and sorption equiliberia at the solid-liquid phase interface in the vicinity of the plant roots [1].

Copper

Copper is one of essential elements for plants and animals. Fumes of copper may cause metal fumes fever with flu like symptoms and hair and skin discoloration while dermatitis has not been reported The most common sources for copper distribution on soils are pesticides, fertilizers, industries and sewage sluges. Critical concentration for copper in plants is between 20 and 100 mg/kg. Copper dust and fumes can cause irritation of the upper respiratory tract, metallic taste in the mouth and nausea [13].

The concentration of copper was found high in the soil from Nowshera and Charsada than the other areas. Plants grown on the three spots contained significantly different amount of copper, due to the difference in the concentration of copper in the soils of the three spots. Looking to the table the copper has not a regular distribution pattern, but has more quantity in roots and leaves, specially with more copper in soil the leaves has comparatively low amount of copper. Thus the copper concentration in plant parts was in the order roots > leaves > stem. The internal concentration of the Cu vary less, although the soils differ strongly with respect to metal concentration and soil properties [1].

Nickel

Nickel is an abundant element. It is found in the form of nickel oxides and sulphides in the environment [14]. It is found in all soils and is emitted from volcanoes. The most common ailment arising from nickel or its compound is an allergic dermatitis known as nickel itch. Nickel is carcinogenic in nature and adversely affects lungs and nasal cavities.

The concentration of nickel was more in Nowshera and Charsada and least in the Bara area. But the concentration was more in stem and least in roots in all samples except one from Pabbi which has the reverse order *i.e.* roots > leaves > stem.

Iron

Iron is another essential element for plant and animal growth. Its deficiency can cause various types of diseases; it is a source of oxygen transport in the blood [15]. The soil samples collected from the five spots showed significant difference between the amount heavy metals (Table-1). The plant samples collected from the spots have different amount of iron. For example, high amount of iron was found in the leaves followed by roots and then stem. The general order for iron content in soil was Nowshera > Charsada > Peshawar> Pabbi> Bara.

Manganese

Manganese is an essential element for plant and animal growth. Its uptake is controlled metabolically. Soil derived manganese from the parent material and its content in the rocks are higher than the concentration of other micronutrients apart from iron [16]. The main sources for manganese in soil are fertilizers, sewage sludges and ferrous smelters. Critical manganese concentration in soil is rather high 1500-3000 mg/kg [17, 18] and critical concentration in plant is in the range of 300-350 mg/kg. There is a general trend for it is leaves > roots > stem in the three spots but for Charsada and Bara the trend is leaves > stem > roots. Thus the concentration level

Table-1: The metal contents in different parts of plant and in soil samples (ppm).
Plant = *Cannabis sativa*

Samples	Cu	Ni	Fe	Mn	Zn	Cr	Pb	Co
Location = Charsada								
Root	0.16	0.01	1.61	0.16	0.33	0.11	0.01	0.04
Leave	0.06	0.07	7.01	0.50	0.37	0.13	0.02	0.07
Stem	0.18	0.09	0.09	0.25	0.38	0.17	0.05	0.00
Soil	0.80	0.43	197.00	28.76	5.36	2.26	0.69	0.50
Location = Pabbi								
Root	0.20	0.06	14.36	0.34	0.39	0.14	0.01	0.00
Leave	0.20	0.04	11.74	0.87	0.44	0.11	0.06	0.00
Stem	0.13	0.03	1.92	0.21	0.23	0.10	0.00	0.02
Soil	0.70	0.41	180.00	23.46	3.51	2.15	0.53	0.23
Location - Nowshera								
Root	0.23	0.09	14.75	0.32	0.45	0.15	0.03	0.05
Leave	0.17	0.14	12.03	0.59	0.40	0.12	0.05	0.08
Stem	0.19	0.16	7.09	0.26	0.41	0.19	0.06	0.01
Soil	0.92	0.47	202.00	24.33	6.45	1.80	0.71	0.40
Location =Peshawar								
Root	0.19	0.06	6.09	0.21	0.35	0.13	0.03	0.03
Leaf	0.12	0.08	8.75	0.25	0.30	0.10	0.04	0.04
Stem	0.14	0.08	6.05	0.13	0.32	0.11	0.03	0.02
Soil	0.76	0.39	190.00	26.06	5.86	2.96	0.71	0.49
Location - Bara								
Root	0.16	0.02	8.51	0.20	0.19	0.06	0.03	0.04
Leaf	0.19	0.07	9.02	0.33	0.27	0.08	0.07	0.02
Stem	0.11	0.05	8.50	0.37	0.21	0.04	0.04	0.01
Soil	0.56	0.31	166.00	25.39	4.10	2.35	0.51	0.41

of manganese is well below the critical level and hence acceptable at this level, because it does not affect the plant growth nor will cause pollution.

Zinc

Zinc is an essential trace element in nutrition. It is used in galvanization, alloy formation, as a protective coating to prevent corrosion. This is also used in the purifying fats for soaps, bleaching bone glue and manufacturing of sodium hydrosulfite. Inhalation of Zn may result sweet taste, throat dryness, cough, weakness aching, fever, nausea and vomiting. It plays an important role in wound healing and its addition to the diet accelerates the growth of delayed sexual development. Its deficiency causes loss of sense of touch and smell. The recommended dietary allowance is 12-15 mg [19].

The high amount of zinc was detected in the soil sample from Nowshera (6.45 mg/kg) followed Peshawar (5.86 mg/Kg) and Charsada (5.36 mg/Kg). The soil from Pabbi has the least amount of zinc (3.51 mg/Kg).

Chromium

Chromium is one of the known environmental toxic pollutants in the world. The main sources of chromium contamination are tanneries, steel industries and sewage sludges application and fly ash. Besides these chromium plating and alloys in motor vehicles is considered to be a more probable sources of chromium [20, 21]. At an elevated concentration it could be toxic for plant and animals. Concentration between 5-30 mg/kg is considered critical for plants and could cause yield reduction. The problems that are associated with chromium exposure are skin rashes, upset stomach ulcers, respiratory problems, weakened immune systems, kidney liver damage, alteration of genetic material lung cancer and ultimately death [17, 20].

Soil samples collected from five different locations (Table-1) showed significantly different amounts of chromium. In case of the plants high chromium was found in plants collected from *Charsada* (Table-1). For example in case of this location high concentration was found in their stem 0.17 mg/kg followed by leaves 0.13 mg/kg. Although chromium was also present in the roots, stem and leaves in other locations, however the concentration in *Bara* area plant is not significant except leaves *i.e.* chromium is present in low concentration (Table-1). In general the concentration of chromium is in the order Peshawar > Bara > Charsada > Pabbi > Nowshera, while among the plant parts the aerial portion has larger quantity than roots. This also shows the excreting channel of the chromium from the plant body through leaves.

Lead

Lead is regarded as highly hazardous for plants, animals and particularly for microorganisms. The main sources of lead pollution of agricultural and plants are lead mines, fuel combustion, sewage slug applications and farmyards manure. The maximum acceptable concentration for foodstuff is around 1 mg/kg. Long-term exposure to lead can result in a built of lead in the body and more severe symptoms. These include anemia, pale skin, a decrease handgrip strength, abdominal pain, nausea, vomiting and paralysis of the wrist joint. Prolong exposure may also result in kidney damage. If the nervous system is affected, usually due to very high exposure, the resulting affects include severe headache, coma, delirium and death. Continued exposure can lead to decreased fertility and/or increase chances of miscarriage or birth defects [22, 23].

As can be seen from Table-1, high lead concentration was found in the aerial parts (stem and leaves) of the plants collected from all the five locations. The overall lead was more in the soils of populous locations of Peshawar and Nowshera followed by Charsada and Pabbi, while the soil sample from small town of Bara has the small amount of lead. In case of Nowshera, high concentration was found in the stem 0.06 mg/kg followed by leaves 0.05 mg/kg. Thus lead concentration was in the order of leaves > stem > roots except in Charsada and Bara where the lead concentration is in the order of stem .> leaves > roots. Obviously the high lead concentration in the above ground parts is due to air borne lead and also due to getting the fast steady state equilibrium [21].

The plants from the five different environments accumulated different amount of lead. The most sensitive was being Nowshera and least one was Pabbi.

Cadmium

Cadmium is toxic metal and can cause serious health problems. Recently attention has been focused for its availability in water, soil, milk, dietary, medicinal plants and herbal drugs etc. The most common sources for cadmium in soil and plants are phosphate fertilizers, non-ferrous smelters, lead and zinc mines, sewage slugs application and combustion of fossil fuels [16, 24]. Critical level for cadmium in soil is between 3-5 mg/kg [25]. At this level in most cases it cannot cause toxic or excessive accumulation concentration in plants or the lowest level of the element concentration in plants that can cause yield reduction is between 5-30 mg/kg. Luckily no cadmium was detected in the plant samples collected from all of the five locations.

Cobalt

Cobalt is a natural earth element present in trace amounts in soil, plants and in our diet. Cobalt occurs naturally in various forms in our environment. Natural sources of cobalt in the environment are soil, dust seawater, volcanic eruptions and forest fires. It is also released to the environment from burning coal and oil, from car, truck and airplane exhausts, and from industrial processes that use the metal or its compounds. Toxic effects on plants are unlikely to occur below soil cobalt concentrations of 40 ppm. However, concentration in the soil is not the only factor determining toxicity. Plant species vary in their sensitivity to cobalt, and soil type and soil chemistry greatly influence cobalt toxicity. One of the most important soil properties is soil acidity. The more acidic the soil, the greater the potential for cobalt toxicity, at any concentration [26, 29].

Experimental

Samples of *Cannabis sativa* were collected from different location of Peshawar Valley and authenticated by Mr. Shahid Farooq Plant Taxonomist of PCSIR Labs. Complex Peshawar, Pakistan. After washing thoroughly with tap water, finally with distilled water, the samples were dried at 60 °C in an oven and stored carefully in dry clean polythene bags. Each dried sample was converted into a finely powdered form by putting it in an agate vibratory disc mill to pass through a 1.3 mm stainless steel sieve. For extraction of the metals, oxidative treatment of the sample was performed [28]. Dry ashing of the plant material was done by placing one gm sample in a pre-weighed porcelain crucible and was ignited for 6 hours at a temperature not exceeding 600 °C in a muffle furnace [29]. The ashed sample was transferred to a beaker containing 10 ml of 20 % extra pure grade HCl and was digested in a water bath for 20 min. The resulting solution was filtered through an ultrafilter membrane having 0.8 μm pore diameter. The filtrate was diluted to 100 ml by the addition of sufficient amount of deionized water and was run for the quantitative determination of Cr, Pb, Cu, Cd, Fe, Ni, and Mn metals, using Perkin Elmer AAS, under the standard conditions of measurement.

Conclusion

The study showed that plant grown on contaminated area has high risk of having the heavy metal concentration beyond the permissible limit for each of them as compared to the less contaminated area. The people generally use herbal medicine for prolonged period of time to achieve desirable effects. Prolong consumption of such herbal medicine might produce chronic or subtle health hazards. Thus our finding indicate that the medicinal plant or plant parts used for different types of diseases must be checked for heavy metal contamination in order to make it safe for human consumption. In other words for local or pharmaceutical purposes, it should be collected from area not contaminated with heavy metals. Thus we advise the readers to check the heavy metal's contents in the medicinal plants even if it was collected from less populated area, before their use for local and pharmaceutical purposes.

References

1. M. Vijver, T. Jager, L. Posthuma and W. Peijnenburg, *Envirnomental Toxicology and Chemistry*, **20**, 712 (2001).
2. S. Takacs and A. Tatar, *Environ. Res.*, **42**, 312 (1987).
3. S. Takacs, *Gyogyfurdougy,* **1**, 29 (1978).
4. World Health Organization, *Quality Control Methods for Medicinal Plant Materials*; WHO Geneva: Switzerland, (1998).
5. K. Nogawa, *Itai-itai Disease and Follow up Studies*, "*Cadmium in the Environment*" Part 2 In: Nariagu Jo, Editor. Wiley Interscience publication John Wiley and Sons: Inc., Canada, **1**, p 1-34 (1981).
6. J. M. Garry and W. D. Phillips, *Environ Hlth Perspect.*, **108**, 413 (2000).
7. M. Shumacher, M. A. Bosque, J. L Domingo and Carbella, *J. Bull Environ Toxicol.*, **46**, 320 (1991).
8. Wealth of India Vol. Thakur, R. S. Puri and H. S. Hussain, A. *Major Medicinal Plants of India, Central Institute of Medicinal and Aromatic Plants*; Lucknow: India, p 249 (1989).
9. The Commercial Products of India by Sir George Watt, Printed by Hazel, Watson and Viney LD. London (1958).
10. The Wealth of India, Raw Material Vol. II. by CSIR India, Published by CSIR, Delhi, p. 58 (1950).
11. Medicinal Plants of East and South East Asia: Attributed Properties and Uses by Lily M. Perry ad Judith Metzger, The MIT Press Cambridge, P 67 (1980).
12. Indian Materia Medica by A.K. Nadkarni Vol. I, Popular Book Depot Bombay 7, P 261, (1957).
13. T. C. Broyer, C. N. Johnson and R. E. Paul, *Plant and Soil*, **36**, 301 (1972).
14. Encyclopedia Britinica London, vol. **12**, p 648.
15. Herbal Foods and its Medicinal Values by H. Panda, National Institute of Industrial Research, 106-E, Kamila Nagar, Delhi-110007, (India), P 35 (2007).
16. M. B. Mc Bride, *Jr. Environ. Qual.* **24**, p 5 (1995).
17. A. K. Pendias and H. Pendias, *Trace Elements in Soils and Plants*, 1st. ed. Boca Raton, Fl: CRC press, p 365 (1984).
18. K. A. Smith, *Manganes and Cobalt in Heavy Metals in Soils*, Ed. B. J. Alloway, Blackie: Glasgow, p 197, (1990).
19. Y. Nergus, S. I. Ahmad and M. Sharif, *J. Chem. Soc. Pak.*, **27**, 561 (2005).
20. S. P. McGrath and S. Smith, *Chromium and Nickel in Heavy Metals in Soils*, Ed. B. J. Alloway, Blackie: Glasgow, p 125, (1990).
21. D. G. Shaheen, *Environ. Pot. Agency Report*, EPA 600/2-75-004, (1975).
22. V. D. Zheljazkov, *Heavy Metal Content in some Essential Oils and Plant Extracts, International Society for Horticultural Science, Amherst,* USA: pp 429, (1995).
23. K. Issermann, *Environ. Pollution,* **12**, 199 (1977).
24. B. E. Davies, *Cadmium in Heavy Metals in Soil*, Ed. B. J. Alloway, Blackie: Glasgow, p 100, (1990).
25. A. K. Pendias and H. Pendias, *Trace Elements in Soils and Plants*, 2nd. ed. Boca Raton, Fl: CRC press, p 365, (1992).
26. R. L. Chaney, *Environmental Chemistry of the Elements*, Academic Press, London, *Jr. Environ. Qual* (1982).
27. R. Frank, K. Ishida and P. Suda, *Can. J. Soil Sci.*, **56**, 181 (1976).
28. B. Markert, *Instrumental Multielement Analysis in Plant Materia Serie Technologia Ambiental*, Rio de Janeiro: **8**, p 1-26, (1995).
29. P. Elmer, *A Catalogue on Atomic Absorption Spectrophotometer* (AAS), No: 3300 USA: Ay-3 to Ay-5, (1982).