ORIGINAL ARTICLE

Lead Testing in Soil Contaminated with Pesticides and Reducing its Effects by the Activity of Activated Charcoal

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Abstract:

Background: Lead poisoning is classically defined as exposure to high levels of lead typically associated with severe health effects, but being a heavy metal which is potentially toxic, if present at even minor concentrations, it is of great concern to environmentalists and medical professionals alike. Activated charcoal has been known to adsorb heavy metals and thus, was used in this study as well. *Aim:* The main aim of this study was to decrease the lead content of agricultural soil which is attributed to the use of pesticides containing lead by using activated charcoal. *Material and Methods:* The lead contamination in agricultural soil and plant dry mass samples which increases due to the effect of pesticides was detected by using Field Portable X-Ray Fluroscence (FP-XRF) spectrophotometer. Soil was taken in plastic trays and the plants were grown and watered daily. The collected ground water was also tested. For the estimation of lead in water samples, Graphite Furnace Atomic Absorption Spectroscopy (GFAAS) was employed. *Results:* This study suggested the remediation of soil lead content by using activated charcoal. The study also revealed that activated charcoal not only adsorbs lead but also inhibits the accumulation of lead in ground water. *Conclusion:* This study promotes a cost effective process to treat agricultural lands polluted with leaded pesticides. Water purifiers, refrigerator etc. contain varying amounts of activated charcoal, after usage of these appliances it can be recycled and used as a source of activated charcoal. This can be applied in pesticide contaminated fields either in the form of slurry or by spraying.

Keywords: Activated Charcoal, FP-XRF, GFAAS, Recycled, Plant Dry Mass, Soil Lead.

Introduction:

Lead poisoning has a drastic effect on public health for centuries. Lead is a cumulative poison, exposure to it and its compounds is toxic to humans and affects ecosystem severely. Nowadays, it has become one of the important chronic environmental illnesses affecting present generation. Many major steps are taken to overcome this problem but serious cases of lead poisoning still appear in hospitals, clinics, and private physicians. Lead is non-biodegradable. It persists in soil, air, drinking water, and in houses. It crosses all social, economical and geographical lines. Once lead is mined and transformed into synthetic products, which are dispersed throughout the environment, lead becomes highly toxic [1]. Lead is a chemical element with symbol Pb (from Latin: *plumbum*, "pipe metal") and atomic number 82. Excessive amount of lead in body causes blood disorders in mammals. Lead interference with heme synthesis which is built-up of heme precursors, such as aminolevulinic acid, which is directly or indirectly harmful to the neurons [2]. Lead hydrogen arsenate which is also called lead arsenate having chemical formula of $PbHAsO_4$, is an inorganic insecticide used primarily against the potato beetle. Lead arsenate adhered to the surfaces of plants and can sustain longer if not treated. Lead may accumulate in the soil, particularly in soil with a high organic content [3]. Lead enters an ecosystem by means of atmospheric lead (primarily from automobile emissions), paint chips, used ammunition, fertilizers and pesticides and lead-acid batteries or other industrial products. Lead which is deposited on the ground is transferred to the upper layers of the soil surface, where it may be retained for many years (up to 2000 years). In cultivated soils, this lead is mixed with soil to a depth (i.e., within the root zone). Atmospheric lead is deposited in the soil which will continue to move into the micro-organism and grazing food chains, until equilibrium is reached. Extensive use of industrially-produced pesticides in agricultural land results in contamination of soil ecosystems [4]. Pesticides used in fields get retained in upper layer of soil. Not only lead in pesticides pollutes the soil and its habitants but also accumulates in the plants treated with leaded pesticides, leading to bioaccumulation by entering the food chain. Lead also pollutes the ground water by accumulating in plant roots and thus entering the water table.

Material and Methods:

Study I: Estimation of Lead in Agricultural Soil and Pesticide:

Sampling of agricultural soil and pesticide was done and both were examined for lead content-Soil was collected in a lead free polythene bags from agricultural field located in Varthur Kodi, Bangalore. Soil and methyl parathion pesticide was collected separately in a lead free polythene bags. Testing was done on the agricultural soil and pesticide, using FP-XRF spectrophotometer.

Study II: Estimation of Lead in Agricultural Soil Samples and Plant Dry Mass:

Activated charcoal was ordered from Aqua Diagnostic Water Research & Technology Centre Limited, Bangalore. Activated charcoal was taken for adsorption of lead from the soil (soil remediation) because of its high porosity and its specific surface area.

Three trays were taken, first tray was kept as control tray (Tray 1), second tray (Tray 2) was taken to estimate lead content in pesticide, and third tray (Tray 3) was taken to check the activity of activated charcoal.

Tray 1: The soil was layered in the tray without any stones or any hard material. 25g of methi seeds were sown on top layer of the soil. The soil was watered well daily up to 20 days.

Tray 2: The soil collected from the agricultural field was taken in a tray enough to grow a plant. The soil was treated with 20gm of pesticide named methyl parathion. Methi seeds were sown in the tray uniformly.

Tray 3: The soil collected from agricultural field was taken in a tray. The soil was treated with 20 gm of pesticide. Activated charcoal was applied as a layer on the top of soil with pesticide. Above the layer of activated charcoal a thin layer of soil was applied to support the growth of methi seeds. Methi seeds were sown above it. Amount of lead present in soil was estimated by FP-XRF spectrophotometer on day 5, 10 and 15 days.

Estimation of Lead in Plant Dry Mass:

After 20 days of estimation of lead in soil the methi plants were plucked from the trays (control, tray 1, and tray 2) and the soil stuck to plant roots was discarded. The plants were dried in sunlight for 15 days. The dried plants were finely powdered with a mortar and pestle. The powders of plants of three trays were taken in 3 plastic bags (free from lead) separately. The lead content in the plant dry mass was estimated using FP-XRF spectrometer.

Study III: Estimation of Lead in Soil, Activated Charcoal and Groundwater in a Series of Three Trays

Three trays were taken and at the bottom of each tray holes were made with a fine needle to allow water passage. In the top tray a layer of soil was applied and above it a thin layer of activated charcoal was applied and in the top layer, soil treated with pesticide was applied. In the second tray the same layers (soil, activated charcoal and soil treated with pesticide) were applied. Third tray was kept empty for collecting water percolating from the two upper trays. The trays were kept above each other and the empty tray was kept at the bottom. The top tray was watered twice a day. Soil of layer 1(soil treated with pesticide) was collected and estimated for lead. The same was done to the soil present beneath the layer of activated charcoal. Activated charcoal layer was estimated for lead by FP-XRF spectrophotometer.

Estimation of Lead in Activated Charcoal Showing its Activity of Adsorbing Lead:

From the second tray the layer of activated charcoal was taken for estimation of lead to determine whether activated charcoal had absorbed lead or not. On the first day a small portion of first layer of soil treated with pesticide was gently removed, then after activated charcoal sample was taken. On the 20th day the above layer of soil treated with pesticide was removed and sample of activated charcoal was taken. Precaution was taken at the time of removing the first layer of soil with pesticide by avoiding contact with activated charcoal layer. Estimation of lead in both the samples was carried out by using FP-XRF spectrophotometer.

Results:

Study I: Estimation of Lead in Agricultural Soil and Pesticide:

The test was done prior before starting our analysis work. The soil was made even so that no stone or other impurities should be there at the time of estimation. In the soil sample the lead concentration was found to be <11 ppm which means lead is not detected in soil sample and was below the average value and thus is not harmful. In pesticide the lead concentration was found to be 13 ppm, which indicated that lead was detectable in pesticide and was above average value and thus it was harmful. Further analysis was done by taking this soil and pesticide as this study needed the soil which was free from lead to estimate the correct amount of lead.

Table 1: Estimation of Lead in Agricultural Soil and Pesticide

Test Materials	Lead Content Estimated
Soil (Agricultural Area)	<11ppm
Pesticide (Methyl Parathion)	13ppm

Study II: Estimation of Lead in Agricultural Soil Samples:

Tray 1 (Fig. 1): The soil in control tray was estimated for lead by using FP-XRF and found to be not detected (<11ppm). The soil in control tray was estimated for lead in FP-XRF spectrophotometer on day 5. The result indicated the absence of lead. The soil of day 10, in Tray 1 was estimated for lead. The lead content was found to be increased to 14 ppm. The soil in control tray on day 15 was not found to be containing lead. Lead in control tray of day 20 was estimated in the FP-XRF spectrophotometer to be 13 ppm.

Fig. 1: Methi Plants Grown on Agricultural Soil.

Tray 2 (Fig. 2): On day 1, the soil was estimated for lead after mixing with pesticide. It gave a value of 13 ppm in FP-XRF spectrophotometer. On day 5, when the soil mixed with pesticide was estimated for lead, it was detected to be 12 ppm. When the soil mixed with pesticide was estimated on day 10 it was detected to be 14 ppm.

Lead in soil with pesticide in tray 2 was estimated on day 15 as 16 ppm, lead was detected in higher amount in this case. On day 20, the soil mixed with pesticide was estimated for lead and was found to be drastically increased to 18 ppm.

Tray 3 (Fig. 3): The soil with pesticide, after layering activated charcoal and soil above it, was estimated for lead in FP-XRF Spectrophotometer. The level of lead was detected as 12 ppm. On day 5, the soil with pesticide present below the layer of activated charcoal in tray3 was estimated for lead. It was not detected by FP-XRF spectrophotometer. On day 10, the lead was found to be absent in the soil beneath the activated charcoal. On day 15, the soil with pesticide below the layer of activated charcoal was estimated for lead and it was found to be absent. On day 20, lead was absent in the soil with pesticide layer.

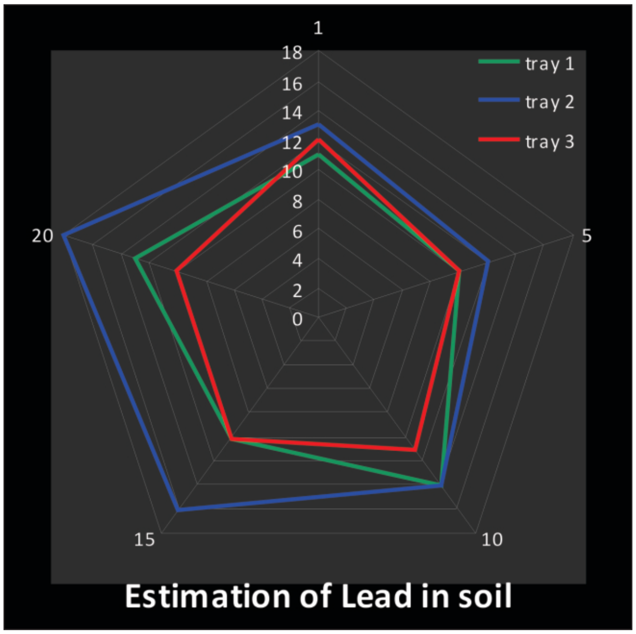
Fig. 2: Methi Plants were Grown on Agricultural Soil Treated with Pesticide.

Fig 3: Methi Plants were Grown on Agricultural Soil Containing Pesticide and a Layer of Activated Charcoal

Table 2: Estimation of Lead in Soil Samples

Sr. No.	Trays	Lead Content (ppm)				
		Day 1	Day 5	Day 10	Day 15	Day 20
1	Soil (Tray 1)	Not detected (< 11ppm)	Not detected	Detected (14 ppm)	Not detected (<10 ppm)	Detected (13 ppm)
2	Pesticide + Soil (Tray 2)	Detected (13ppm)	Detected (14ppm)	Detected (14 ppm)	Detected (16 ppm)	Detected (18 ppm)
3	Pesticide + Soil + activated charcoal (Tray3)	Detected (12 ppm)	Not detected	Not detected (<11 ppm)	Not detected (<10 ppm)	Not detected (<10 ppm)

In the graph, the concentrations of lead in three trays were represented, against the number of days for which the soils were incubated with leaded pesticide.



Graph 1: Estimation of Lead in Soil Treated With Pesticide

Tray 1: The graph represents the initial concentration of lead in green tray as <11ppm (not detected), same concentration on day 5 to 11ppm. On day 10 there was no increase in concentration than 11ppm, and this increased to 13ppm when the incubation time reached day 20.

Tray 2: In the blue tray having soil mixed with pesticide, the graph indicated the increase in value of lead concentration from 13 ppm on day 1 to 14 ppm on day 5. On day 10 the lead concentration was same 14 ppm. From day 10 to day 20, there was a drastic increase in a lead content from 14 ppm to 18 ppm.

Tray 3: In the red tray having activated charcoal with soil mixed with pesticide the graph indicate the continuous decrease in value of lead concentration from 12 ppm on day 1 ppm to <10ppm (not detected) on day 5,10 and 15.

Estimation of Lead in Plant Dry Mass of Methi Plants:

The methi plants grown in tray 1, tray 2 and tray 3 were plucked after 20 days of growth. These plants were dried in sun and crushed to powder. Then the powders were estimated for lead using FP-XRF spectrophotometer. Plants of tray 1(soil) have lead estimated to be 12 ppm. Plant dry mass of plants grown in tray 2 (soil with pesticide) was found to contain 17 ppm of lead, thus lead concentration was very much higher and would be very harmful if we consumed that plant. Dry mass of plants grown in tray 3 (soil, activated charcoal and soil with pesticide) had no lead in it; activated charcoal adsorbed the lead and not allowed lead to translocate in plant system.

Table 3: Estimation of Lead in Dry Mass of Methi Plants

Sr. No.	Trays	Lead Concentration (ppm)
1	Soil	12 ± 3
2	Soil + Pesticide	17 ± 5
3	Soil + Pesticide + Activated charcoal	< 11

Study III - Estimation of Lead in Soil, Activated Charcoal and Groundwater in A Series of Three Trays

First tray: In the layer containing soil + pesticide was estimated for lead and lead was not detected (<10 ppm). In the layer having activated charcoal, it showed high amount of lead (16 ppm). In the layer containing only soil, lead was not detected (<10 ppm).

Second tray: In the layer containing soil + pesticide and lead was not detected (<10 ppm). In the layer of activated charcoal showed high amount of lead (18 ppm). Layer containing only soil, lead was not detected (<10 ppm).

Table 4: Estimation of Lead in First Two Trays

Sr. No.	Trays	Layers	Day 1	Day 10	Day 20
1	First Tray	Soil + Pesticide	Detected (13 ppm)	Detected (12 ppm)	Not detected (<10 ppm)
		Activated charcoal	Not detected (<10 ppm)	Detected (14 ppm)	detected (16 ppm)
		Soil	Not detected (<10 ppm)	Detected (11ppm)	Not detected (<10ppm)
2	Second Tray	Soil + Pesticide	Detected (13 ppm)	Detected (13 ppm)	Not detected (<10 ppm)
		Activated charcoal	Not detected (<11 ppm)	Detected (16 ppm)	Detected (18 ppm)
		Soil	Not detected (<10 ppm)	Not detected (<11 ppm)	Not detected (<10 ppm)

On day 1, the ground water sample was tested in lab, the lead content was estimated to be <0.0067 mg/L. On day 20, the lead content was estimated to be <0.005 mg/L. This showed that activated charcoal had adsorbed lead in sufficient quantity and did not allow lead to contaminate the ground water.

Table 5: Estimation of Lead in Ground Water Showing Lead Concentration on Day 1 and Day 20

Sr. No.	Ground Water Sample	Lead concentration (mg/l)
1	Day 1 (Initial)	<0.0067 mg/l
2	Day 20 (Final)	<0.005 mg/l

Estimation of Lead in Activated Charcoal Showing its Activity of Adsorbing Lead:

From the three layers (soil, soil treated with pesticide, activated charcoal) activated charcoal layer was taken very cautiously that no other layer should mix on that on Day 1 and Day 20. The sample was examined under FP-XRF spectrophotometer on day 1, the lead was not detected. The another sample was examined under FP-XRF spectrophotometer on day 20, lead was detected 12 ppm, it meant that activated charcoal had absorbed the lead.

Table 6: Estimation of Lead in Activated Charcoal Showing its Activity of Adsorbing Lead

Sr. No.	Activated Charcoal	Lead Concentration
1	Day 1 (Initial)	Not Detected
2	Day 20 (Final)	12 ± 4 ppm

Discussion

Our results shows that how enormous the lead increases after addition of pesticide in the agricultural field and subsequently taken up by the plants and estimation of plant dry mass shows the high concentration of lead in plants. Our study shows that pesticides are the source of increasing lead content in the agricultural soil. Our data shows that how lead increases from day 1(13 ppm) to day 20 (18 ppm), the increase of lead concentration being due to the lead present in the pesticide.

Without the pesticide it has been estimated to be 13 ppm and with application of activated charcoal it has remained below detectable level which proves adsorption of lead by activated charcoal. If we compare the data of our three trays, tray 1 (soil), tray 2 (soil treated with pesticide), tray 3 (soil treated with pesticide and having a layer of activated charcoal), it shows that tray 2 has higher amount of lead concentration because of the pesticides compared to other trays and lead concentration is lower in tray 3 because of the activity of activated charcoal of adsorbing lead. In this study the dry mass of plant has been estimated for lead concentration and the results show a higher concentration of lead in plant dry mass indicating that lead is highly absorbed by the plant. In our study the lead has been estimated by FP-XRF spectrophotometer, which is mainly used for the estimation of metals in soil or in any jewellery and also determination of metals in paints, eatable stuffs etc. GFAAS was used to measure lead content in ground water. Our study successfully shows that the tray 3 containing soil treated with pesticide and a layer of activated charcoal has lesser amount of lead concentration. And our groundwater analysis shows that the activated charcoal adsorbs lead and does not allow lead to contaminate ground water. In this study we have shown a new method for absorbing the lead from the agricultural soil by the activity of activated carbon, it not only absorbs lead but also does not allow lead to contaminate ground water.

Conclusion:

This study investigates that pesticides are one of the main cause of increase in lead concentration in agricultural field and plants, so by using activated charcoal, we can recover the soil from lead toxicity. In accordance with other investigations carried out [11, 12] through this study also, it was shown that activated charcoal absorbs lead and does not allow lead to contaminate ground water. Activated charcoal has prevented lead accumulation in plants and soil thereby preventing passage of lead through the food chain. This study shows the availability of better prospective method to the farmers for lead remediation in soil and preventing ground water from lead contamination by using activated charcoal. This study investigates the most efficient and also cost effective method for remediation of lead in agricultural soil. To achieve this goal, several tests have been conducted with activated charcoal. Results have shown that activated carbon is a very efficient agent for lead adsorption.

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