



**POSSIBLE HEAVY METAL (PB, MN, & CU) ACCUMULATION IN FRESH WATER
AND WASTE WATER IRRIGATED VEGETABLES.**

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ABSTRACT

Anthropogenic water is mostly used for the irrigation of crops either directly or in the form of treated water, mainly in the urban and periurban ecosystem, due to the ease in availability, and scarcity of fresh water. Such type of Irrigation with wastewater is going to influence the accumulation of harmful substances within the living organisms. Heavy metals are non-biodegradable in nature, they have prolonged biological half-lives and moreover they have the potential to accumulate in different body parts. The present study was carried out to estimate the levels of different heavy metals like Lead, manganese and copper, in vegetables (Spinach & Potato) irrigated with water from different sources. The results clearly showed a significant build-up of heavy metals in vegetables irrigated with wastewater when compared with the fresh water. Wastewater-irrigated spinach has shown significantly ($p < 0.05$) higher accumulation of Lead, manganese and copper compared to the freshwater-irrigated spinach, indicating the highest metal absorption. The same results were observed in the potato also. On the other hand the organic cultivars showed relatively less accumulation when compared to fresh water irrigated and waste water irrigated. However, the regular monitoring of loads of these harmful metals from effluents and sewage, in vegetables need to be carefully monitored for preventing them to accumulate in the food chain.

INTRODUCTION

A heavy metal is generally regarded as any relatively dense metal or metalloid of environmental contexts^[1] The term originated with reference to the harmful effects of metals like cadmium, mercury and lead all of which are denser than iron^[2]. Commonly encountered heavy metals are chromium, cobalt, nickel, copper, zinc, arsenic, selenium, silver, cadmium, antimony, mercury, thallium and lead. Criteria used to define heavy metals have included density, atomic weight, atomic number, aqueous chemistry or periodic table position^[3,4]. A density criterion ranges from above 3.5 g/cm³ to above 7 g/cm³. Atomic weight definitions start at greater than 22.98 to greater than 40.

Lead moves into and throughout ecosystems. Atmospheric lead is deposited in vegetation, ground and water surfaces^[5]. The chemical and physical properties of lead and the biochemical processes within the ecosystems will influence the movement of lead through ecosystems. The metal can affect all components of the environment and can move the ecosystem until it reaches an equilibrium^[6]. Lead accumulates in environment, but in certain chemical environments it will be transformed in such a way as to increase its solubility (e.g., the formation of lead sulfate in soils), its bioavailability or

its toxicity^[7]. The affects of lead at ecosystem level are usually seen as a form of stress. In general, there are three known ways in which lead can inversely affect ecosystems. Population of micro-organisms may be wiped out at soil lead concentrations of 1000 parts per million (ppm) or more, slowing the rate of decomposition of matter^[8]. Population of plants, micro-organisms and invertebrates may be affected by lead concentrations of 500 to 1000 ppm, allowing more lead tolerant populations of the same or different species to take their place^[9,5]. This will change the type of ecosystem present. At all ambient atmospheric concentrations of lead, the addition of lead to vegetation and animal surfaces can prevent the normal biochemical process that purifies and repurifies the calcium pool in grazing animals and decomposer organisms.

In fact, there are several sources of contamination, namely natural, agricultural, domestic, atmospheric and other sources^[2]. However tremendous application and utilization of heavy metals in more recent years through industries caused steep emission to our environment.

The main pathways of humans' exposure to these elements are through air, water, soil and hence agricultural crops. The health effects of heavy metals

have been known since ancient history^[10]. In essence, toxicity and/or carcinogenicity of heavy metals, such as lead, arsenic, mercury, cadmium and nickel have been reported in numerous studies, even in low dose exposure^[2,11]. In brief, they may cause kidney, lung, nervous system and skeletal system^[4,5]. Diminished intellectual capacity, gastrointestinal symptoms, coronary heart disease, variety of cancers, such as renal, skin, and bladder cancer, and even death have been also associated with chronic and/or acute exposures to heavy metals^[12]. Living organisms require varying amounts of heavy metals. All metals are toxic at high concentrations. Excessive levels can be damaging the organisms^[3]. Lead interferes with a variety of body processes and is toxic to many organs and tissues including the heart, bones, intestines, kidneys, and reproductive and nervous systems^[13]. It interferes with development of nervous system and is therefore particularly toxic to children, causing potentially permanent and behaviour disorders^[7]. Symptoms include abdominal pain, confusion, headache, anaemia, irritability and in severe cases seizures, coma, and death^[8]. The study was designed to measure the levels of accumulation in the vegetables especially Spinach and Potato. Sampling was done randomly from different market yards. The study was mainly focussed on the samples which were cultivated in fresh water and waste water.

MATERIALS AND METHODS

Study area and sampling: All the experiments were conducted at the Indian Academy degree College laboratory and the samples for AAS were sent for spectroscopic facility, IISC.

Samples of Spinach and potato were collected from different market areas in and around Bangalore. Two samples which were tagged organic were collected from the super markets within the city. Further the samples were also collected and sorted based on the water source they were irrigated with i.e., fresh water and waste water

irrigated. The samples were sorted based on the communication with the farmers and the vegetable vendors.

The samples collected were thoroughly washed with double distilled water to remove airborne pollutants. The samples were cut into tiny pieces and washed, weighed and air-dried for a day, to reduce water content. The samples were further oven-dried at about 70–80 °C for about 24–48h to remove all of the moisture. The samples were further pulverized using a pestle and mortar and sieved through muslin cloth.

Digestion of the vegetable samples: For each sample 0.5gm were accurately weighed and placed in crucibles, three replicants for each sample. The ash was digested with perchloric acid and nitric acid (1:4) solution. The samples were left to cool and contents were filtered through Whatman filter paper No. 42. Each sample solution was made up to a final volume of 25ml with distilled water and analyzed by atomic absorption spectrophotometry. Standard solutions of heavy metals (100mg/l), namely lead (Pb), Mn and Cu were procured from Sigma Aldrich. Solution of different concentrations were prepared for the metal by diluting the standard.

RESULTS AND DISCUSSION

Metal accumulation in vegetables: The results suggests the possible accumulation of heavy metals in the vegetables. The AAS results were done on the triplicates. Standard solutions (100mg/L) of the heavy metals were used as the control. Both spinach and potato showed a load of metals within them. The accumulation of heavy metals was in the order of Pb>Mn>Cu. Fresh waster irrigated samples showed a significantly lower accumulation than the waste water irrigated. And moreover, the organic grown vegetables showed a relatively lower accumulation than the normal vegetation.

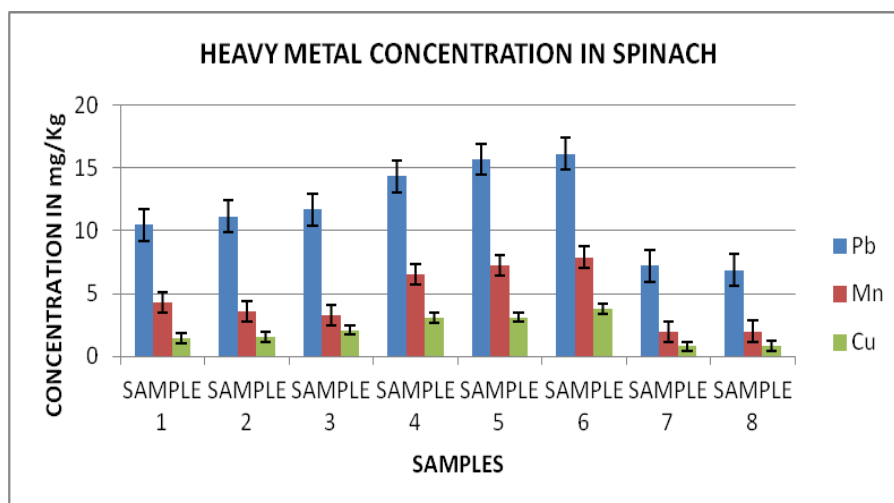


Fig 1: Graph showing the concentration of heavy metals (Pb, Mn & Cu) in Spinach. Sample 1,2,3 were from fresh water irrigated samples. Sample 4,5,6 were from waste water irrigated samples and sample 7,8 were organic cultivars. All the samples were average of triplicates. The values were expressed in mg/Kg.

A two way ANOVA between the samples and the concentration of heavy metals was conducted to compare the accumulation of heavy metals in spinach samples. All effects were statistically significant at the 0.05 significance level. There was a significant effect in the accumulation of heavy metals in all the three samples remembered at the $p < 0.05$ level. The fresh water irrigated samples showed lower accumulation than the waste water irrigated [$F(7,14) = 9.720225$, $p = 0.00019$]

and to the treatments [$F(2,14) = 120.6923$, $p = 0.0759$]. Our results suggest that there was a significant effect on the accumulation of heavy metals among the fresh water, waste water irrigated and organic cultivated. Fresh water irrigated showed lower accumulation than the waste water irrigated and organic cultivated showed significantly lower accumulation than both the fresh water and water irrigated.

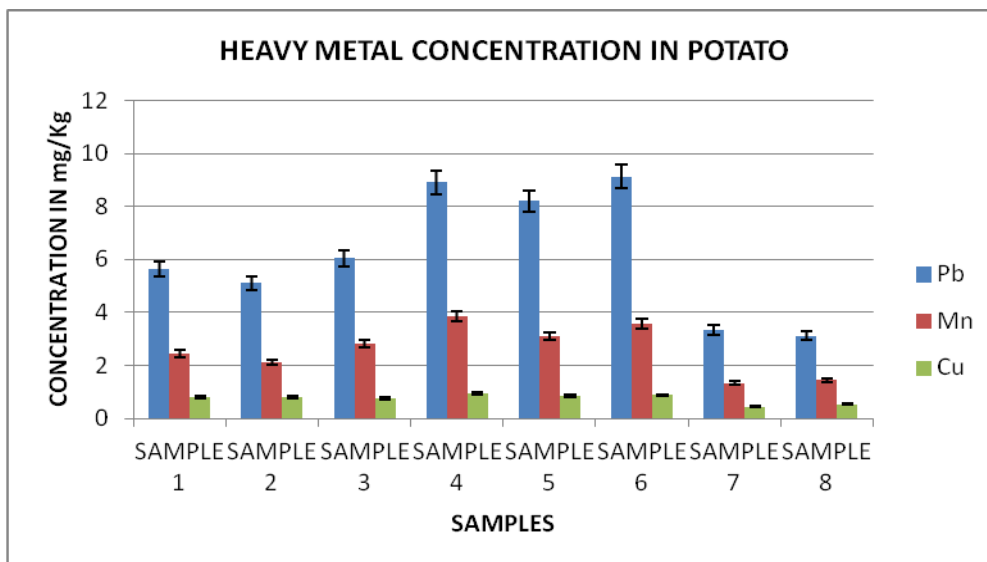


Fig 2: Graph showing the concentration of heavy metals (Pb, Mn & Cu) in Potato. Sample 1,2,3 were from fresh water irrigated samples. Sample 4,5,6 were from waste water irrigated samples and sample 7,8 were organic cultivars. All the samples were average of triplicates. The values were expressed in mg/Kg.

A two way ANOVA between the samples and the concentration of heavy metals was conducted to compare the accumulation of heavy metals in potato samples. All effects were statistically significant at the 0.05 significance level. There was a significant effect in the accumulation of heavy metals in all the three samples remembered at the $p < 0.05$ level. The fresh water irrigated samples showed lower accumulation than the waste water irrigated [$F(7,14) = 3.080744$, $p = 0.034769$]

and to the treatments [$F(2,14) = 47.79191$, $p = 0.0759$]. Our results suggest that there was a significant effect on the accumulation of heavy metals among the fresh water, waste water irrigated and organic cultivated. Fresh water irrigated showed lower accumulation than the waste water irrigated and organic cultivated showed significantly lower accumulation than both the fresh water and water irrigated.

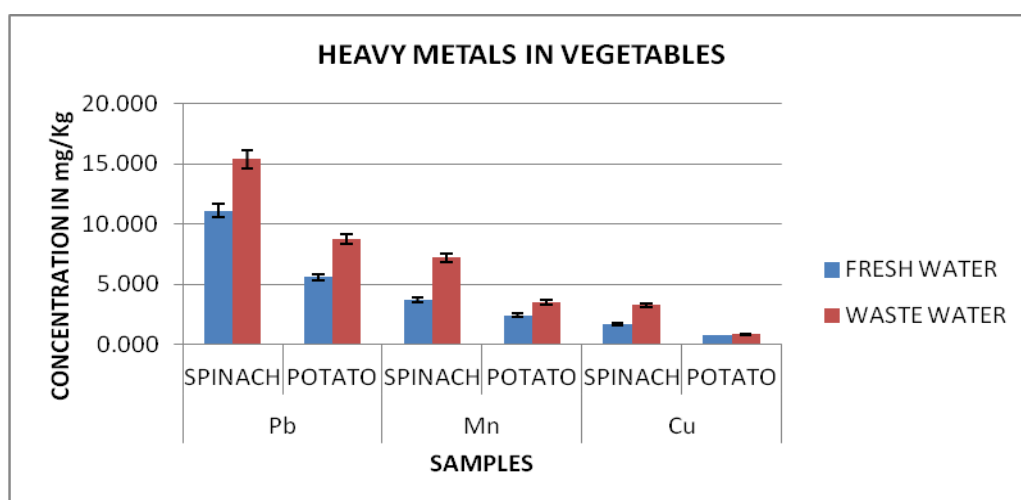


Fig 3: Graph showing the concentration of heavy metals (Pb, Mn & Cu) in Both Spinach and Potato. All the samples were average of triplicates. The values were expressed in mg/Kg.

A comparative study was done relatively between the samples from both fresh water and waste water irrigated and their accumulation levels of heavy metals. Spinach showed more accumulation when compared to potato. And the order of heavy metal accumulation in both spinach and potato was $Pb > Mn > Cu$. Fresh water showed relatively lower accumulation when compared to waste water irrigated. The usage of wastewater might have led to changes in the physicochemical characteristics of soil and consequently heavy metal uptake by vegetables. It is clearly observed that the concentration of all the heavy metals is higher in wastewater-irrigated vegetables than freshwater-irrigated plants.

CONCLUSION

Heavy metals show a relatively significant level of accumulation in wastewater irrigated crops. Wastewater-irrigated spinach has shown significantly ($p < 0.05$) higher accumulation of Lead, manganese and copper compared to the freshwater-irrigated spinach, indicating the highest metal absorption. The same results were observed in the potato also. On the other hand the organic cultivars showed relatively less accumulation when compared to both fresh water irrigated and waste water irrigated. Since both the spinach and potato were consumed in large by the people in and around, it is strongly advisable to consume in less amounts. And moreover regular monitoring of the water supplied for irrigation need to be done. Thus we can prevent the excessive accumulation of the metals in the food chain.

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