Original Research Article

Effect of pharmaceutical effluent on the growth of crops in Nigeria

Abstract

Environmental pollution constitutes a great health hazard to human, animals and plants with local, regional and global implications. Pollution has adverse effects on land, water and its biotic and abiotic components. Effluents from industries are normally considered as the main ~~ustrial~~ pollutants containing organic and inorganic compounds.

This experiment was conducted under laboratory condition to investigate the effect of different heavy metals in pharmaceutical effluent on germination and growth of okro (*abelmoschusesculentus*) and tomato (*lycopersiconesculentum*) seed. The effect of these effluents was compared with control water. The soil on which the plants were grown was analyzed. A control sample watered by de-ionized water was also analyzed. The plant samples were divided into stem, root and leaf prior to digestion and analyzed. The soil and plant samples were digested by wet-oxidation technique and analyzed for heavy metals by atomic absorption spectrophotometer (AAS). Lead, Cadmium, Chromium, Zinc, Copper, Nickel and Iron concentrations were found in tomato (*Lycopersicon esculentum*) and okro (*Abelmoschus esculentus*) plants watered by different concentrations of pharmaceutical effluent. The results stated that the industrial effluents significantly affect germination; root, stem and shoot elongation of the investigated crops with highest concentration found in the root of the investigated plants when compared to the stem and leaf.

Introduction

Pollution of the biosphere by heavy metals due to industrial, agricultural and domestic activities has be considered to be a global problem owing to its serious effects on all forms of life and exposed materials [1, 2]. Pollution of the land occurs from various degradable and non degradable materials. These materials may be solid waste, trash or chemicals. Heavy metal pollution serves as a great threat to the biosphere due to the fact that they cannot be

degraded, rather they persist and are accumulated, hence pose severe effects on humans, animals and plants. They can cause adverse toxic effects on the plants growing in the affected area leading to a decrease in agricultural productivity. Another point of view is that due to high cost and scarcity of chemical fertilizers, the land disposal of agricultural, municipal and industrial waste is widely practiced as a major and economic source of nutrients and organic matter for growing cereal crops by poor farmers in Pakistan [3, 4]. The use of such waste water in irrigation system definitely provide some nutrients to enhance the fertility of soil but also deposit toxicants that change soil properties in the long run. This necessitates a detailed scientific study before any specific waste can be used for irrigation for a particular crop and environmental conditions. Since different crop species may have different tolerance to various pollutants. Seed germination and plant growth bioassays are the most common techniques used to evaluate phytotoxicity [5]. Present study was designed for the assessment and impact of heavy metals in pharmaceutical effluent on germination and growth of okro (*Abelmoschus esculentus*) and tomato (*Lycopersicon esculentum*).

Materials and Methods

Effluent samples were collected from a pharmaceutical company in Ilorin, Kwara State. They were subjected to various physico-chemical tests using the standard methods of Eaton et al., [6]. For the germination experiments, certified seeds of *Abelmoschus esculentus* and *Lycopersicon esculentum* were obtained from NARC, Islamabad. Experimental setup was the same as described by Nawaz et al. [7]. Healthy and equally sized seeds of *Abelmoschus esculentus* and *Lycopersicon esculentum* were sterilized with 0.1% HNO_3. After repeated washings with sterilized distilled water, seeds were soaked in the same water for 4hrs. Then 20 sterilized seeds were arranged in sterilized Petri dishes, lined with double layer of Wattman filter paper No 1. Plates were labeled as per type, concentration of the effluent and variety of ~~lentil.~~ Different concentrations (0, 1, 5, 10, 20, 30, and 40%) of each effluent were made with distilled water. Respective effluent concentration were provided and incubated for three days at 26 ±2^{o}C for germination. Daily observations were made for the germinated seeds. On third day they were shifted to light (10kLux) for next seven days. Before shifting, 10 ml of nutrient solution was provided with the same concentration of effluents. After seven days, seedlings were harvested; root, shoot & seedling lengths and fresh weights were recorded. For dry weights seeds were incubated at 60^{o}C for 24 hrs. Data was subjected to statistical analysis.

Results and Discussion

The mean concentrations of heavy metals (chromium, cadmium, iron, copper, nickel, lead and zinc) in *Abelmoschus esculentus* stem, leaf and root are presented in tables 1 to 3. The samples gave a range concentration value of the 7 elements. The concentrations of the heavy metals in the various samples from the sites were detected using Atomic Absorption Spectrophotometer.

Table 1: Mean Concentration of heavy metals in *Abelmoschus esculentus* Stem

Sample	Concentration (Mean±SD)						
	Zn(mg/kg)	Cu(mg/kg)	Fe(mg/kg)	Cr(mg/kg)	Ni(mg/kg)	Pb(mg/kg)	Cd(mg/kg)
5% OS	16.5±0.125	26.25±0.25	201±0.036	3.33±0.313	11±0.313	7.5±0.125	2.875±0.125
10% OS	32.88±0.338	54.5±0.338	319.5±0.338	8±0.125	10.75±0.55	9.25±0.125	3.625±0.338
20% OS	52.88±14.325	76.38±0.338	393.5±0.213	8.625±0.125	13.02±0.338	11.25±0.25	3.875±0.338
30% OS	69.38±0.125	84.38±0.125	578.875±0.125	10.375±0.338	14.5±0.125	12.625±0.125	5±0.125

Table 2: Mean Concentration of heavy metals in *Abelmoschus esculentus* Leaf

Sample	Concentration (Mean±SD)						
	Zn(mg/kg)	Cu(mg/kg)	Fe(mg/kg)	Cr(mg/kg)	Ni(mg/kg)	Pb(mg/kg)	Cd(mg/kg)
5% OL	105.75±0.338	133.25±0.213	325.625±0.125	3.875±0.338	13.75±0.438	11.5±0.213	6.375±0.125
10% OL	163±0.45	138.75±0.125	477.625±0.125	8.5±0.125	14.75±0.338	12.75±0.338	7.875±0.45

20% OL	238.5±0.45	254.25±0.738	545.25±0.313	8.77±0.125	15.75±0.338	13±0.25	8.583±0.15
30% OL	376.75±0.213	355±0.763	851.75±0.25	9.125±0.338	26.25±0.25	13.75±0.125	9.125±0.338

Table 3: Mean Concentration of heavy metal in *Abelmoschus esculentus* Root

Sample	Concentration (Mean±SD)						
	Zn(mg/kg)	Cu(mg/kg)	Fe(mg/kg)	Cr(mg/kg)	Ni(mg/kg)	Pb(mg/kg)	Cd(mg/kg)
5% OR	112.63±0.13	120.5±0.12	314.75±0.12	4.125±0.213	15.21±1.55	12.25±0.25	7.75±0.338
10% OR	162.75±0.338	205.5±0.125	343.25±0.125	8.5±0.213	15±0.25	13±0.338	8.5±0.213
20% OR	251.38±0.125	196±0.125	701.25±0.125	9.5±0.125	16±0.125	13.75±0.125	8.875±0.338
30% OR	451.25±0.213	492.75±0.125	917.75±0.213	10.25±0.263	17±0.263	14.458±0.263	9.75±0.25

Generally, it is observed that the concentration of all the metals was increasing with increasing concentration of untreated pharmaceutical effluent (table 1-3). Considering the control plant (table 4), the concentration of heavy metals was significantly low.

Table 4: Mean Concentration of heavy metal in control plant.

Sample	Concentration(Mean±SD)						
	Zn(mg/kg)	Cu(mg/kg)	Fe(mg/kg)	Cr(mg/kg)	Ni(mg/kg)	Pb(mg/kg)	Cd(mg/kg)
0%BR	16.25±0.125	23.5±0.125	182.875±0.125	2.625±0.125	10.75±0.25	2.625±0.213	2.25±0.125

The use of many plants for food is often limited by the composition of heavy metals in them as they pose dangerous effects in both man and animals [8]. Heavy metals are environmental pollutants, and their toxicity is a problem of increasing significance for ecological, nutritional, evolutionary, and environmental reasons. The term "heavy metal" refers to any metallic element which has a relatively high specific gravity (typically five times heavier than water) and is often toxic or poisonous even at low concentrations. This group of heavy metals includes lead (Pb), cadmium (Cd), nickel (Ni), cobalt (Co), iron (Fe), zinc (Zn), chromium (Cr), arsenic (As), silver (Ag), and the platinum group elements [9]. Some of the heavy metals (Fe, Cu, and Zn) are known to be essential for plants and animals [10]. Other heavy metals such as Cu, Zn, Fe, Mn, Mo, Ni, and Co are essential micronutrients [11], excess uptake of which by plants results in toxic effects [12, 13].

Cu is an essential micronutrient, exposure to excess Cu has a detrimental effect on plant growth. In the table above, the concentration of Cu was high in the root compared to the stem and leaf of *Abelmoschus esculentus*. Marschner [14] reported that Cu tends to accumulate in the root tissue of plants and simultaneously translocate to the shoots. The concentration of Cu in the root tissue of *Abelmoschus esculentus* ranges between 120.5 to 492.75 mg/kg which is far above the range of 80-100 mg/kg suggested by Marschner [14] as a general critical concentration for Cu toxicity. The effect of Cu toxicity on root morphology is similar to that of chromium toxicity [15]. Both affect root proliferation and reduce root hair formation and hence, affect nodulation. Similarly, iron is an essential micronutrient and the third most limiting nutrient for plant growth and metabolism, primarily due to the low solubility of the oxidized ferric form in aerobic environments [16, 17]. The concentration of iron in *Abelmoschus esculentus* was generally high in the root compared to the stem and leaf and consequently above optimal level [18]. Iron toxicity promote the formation of reactive oxygen-based radicals, which are able to damage vital cellular constituents (e.g., membranes) by lipid peroxidation which are often characterized by bronzing (coalesced tissue necrosis), acidity, and/or blackening of the roots [19].

Tables 5 to 7 presents the mean concentrations of heavy metals (chromium, cadmium, iron, copper, nickel, lead and zinc) in *Lycopersicon esculentum* stem, leaf and root.

Table 5: Mean Concentration of heavy metal in *Lycopersicon esculentum* stem

Sample	Concentration (Mean±SD)

	Zn(mg/kg)	Cu(mg/kg)	Fe(mg/kg)	Cr(mg/kg)	Ni(mg/kg)	Pb(mg/kg)	Cd(mg/kg)
5% TS	8.5±0.125	21.75±0.125	175.125±0.213	2.25±0.25	9.75±0.125	8.375±0.125	2.375±0.125
10% TS	67.13±0.213	46±0.125	279.5±0.25	5.25±0.213	12.92±0.525	10.125±0.125	2.625±0.125
20% TS	35.25±0.213	63.88±0.125	367.5±0.125	6±0.213	13.63±0.213	11.875±0.325	3.625±0.125
30% TS	39.25±0.5	70.25±0.125	455.96±0.375	7±0.338	14±0.25	13.292±0.263	3.875±0.213

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112 Table 6: Mean Concentration of heavy metal in *Lycopersicon esculentum* leaf

Sample	Concentration (Mean±SD)						
	Zn(mg/kg)	Cu(mg/kg)	Fe(mg/kg)	Cr(mg/kg)	Ni(mg/kg)	Pb(mg/kg)	Cd(mg/kg)
5% TL	112.63±0.125	101.38±0.188	147.75±0.213	3.75±0.125	12.5±0.25	12.25±0.125	5.25±0.338
10% TL	155.38±0.188	127.63±0.213	251.25±0.125	4.875±0.45	13.88±0.125	12.875±0.338	6±0.125
20% TL	225.5±0.213	81±0.125	362.625±64.84	5.25±0.25	14.25±0.213	12.75±0.338	7.75±0.213
30% TL	360.25±0.025	298.25±0.213	418.25±0.125	6.625±0.65	14.88±0.125	13.875±0.125	8.25±0.125

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114 Table 7: Mean Concentration of heavy metal in *Lycopersicon esculentum* root

Sample	Concentration (Mean±SD)

	Zn(mg/kg)	Cu(mg/kg)	Fe(mg/kg)	Cr(mg/kg)	Ni(mg/kg)	Pb(mg/kg)	Cd(mg/kg)
5% TR	113.13±0.213	102±0.125	148.5±0.213	3.875±0.125	12.63±0.213	12.625±0.125	5.375±0.125
10% TR	157.875±0.125	129.5±0.213	262.625±0.125	4.75±0.25	14.25±0.438	14.58±0.188	6.125±0.34
20% TR	220.25±0.375	251.75±0.575	252.417±0.263	5.625±0.125	14.75±0.125	14.375±0.213	7±0.125
30% TR	363.75±0.338	298.25±0.125	455.5±0.125	7.25±0.21	15.13±254.3	14.75±0.25	8.625±0.125

From the tables (5-7) above, it is observed that the concentration of the metals increased with increasing concentration of the effluents in the entire samples (stem, leaf and root) with the root being highest. All the investigated heavy metals are significantly higher than the tolerable values for plants [18].

Lead is a major environmental pollutant of world-wide concern that accumulates in soils [20]. It is known to exert its toxic effect on plants by causing a rapid inhibition of root growth, probably due to the inhibition of cell division in the root tip [21]. It has been reported to have similar mechanism in several plants species, including *Triticum aestivum* [22, 23], *Z. mays* L. [24], *Pisum sativum* [25]. This effect on root growth has been shown to be similar to that of nickel toxicity [26, 27].

Conclusion

From the present study it could be concluded that the effluent from pharmaceutical companies are toxic and consequently affect the growth of plants. All the studied metals are significantly higher in concentration compared to the control group and as well higher than the permissible limit by world health organization. The increase in the values of these elements from the control might be as a result of these elements present in soil and pharmaceutical effluent as well as the plant itself.

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