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ASSESSING HEAVY METAL CONTAMINATION IMPACT IN MAIZE GROWING ALONG THE ROADSIDE

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ABSTRACT

Now a days heavy metal contamination along the roadside is a matter of concern especially in industrial areas of developing countries. The non-degradable nature of heavy metals makes them injurious to all living beings. Soil, dust, and plants are the main media for the entry of these metals into our food chain. Thereby, a survey was conducted to assess the nickel (Ni), copper (Cu) and manganese (Mn) levels in roadside dust, soil and maize crop growing along the roadside. Moreover, the effects of these metals were also assessed on the growth and physiology of maize. Plant, soil, and dust sample were collected from Millat road Faisalabad. Samples were collected from four sites at three different distances (10m, 30m, 60m) from the road. Each site had a distance of 5 km from the other site. As result, metal concentration in soil, dust and maize decreased with increasing distance from the road ($P \geq 5$). Maximum metal concentration in dust, soil and plant was noted at the distance of 10m (Cu 40.1, Mn 189.66 and Ni 5.6 mg kg^{-1} in soil; Cu 11.3, Mn 179.7 and Ni 9.37 mg kg^{-1} in dust; Cu 11.8, Mn 23.01 and Ni 3.75 mg kg^{-1} in plant) from the roadside. Likewise, maize plants near the roadside showed more metal concentration with retarded growth and physiology.

Keywords: contamination, dust, environmental degradation, heavy metal, roadside

INTRODUCTION

Heavy metals refer to inorganic elements with a density > 5g cm^{-3} which are non-biodegradable and persistent in the environment. The contamination of soil and water over the years by toxic heavy metals has become a major concern for soil, water and air. Metal contamination has a mutagenic, genotoxic and cytotoxic impact on a living organism (Romdhane *et al.,* 2021). Heavy industries (Coal combustion, power plants, metallurgical industries, chemical plants, and auto repair shops) are metal contamination sources. Due to the overflow of hazardous wastes such as toxic liquids and gases, which can pollute drinking water, reduce soil quality, and release toxins in the air, industries has become very important in terms of environmental degradation (Hanfi *et al.,* 2020). Juwah and Tachere, (2021) highlighted vehicular emissions as a major source of heavy metal pollution has negative effects on the ecosystem. Metal contamination causes variation in plant growth and physiology of roadside plants. Leaves of roadside plants area reservoir for noxious emission through vehicles (Juwah and Tachere, (2021). Plants growing on metal-contaminated sites exhibited metabolic changes, reduced growth, reduced biomass production, and reduced metal accumulation. Various physiological and biochemical processes of plants are affected by Roadside metals (Nagajyoti *et al.,* 2010). Roadside surroundings like auto repair shops, brake lining wears and industries are a big source of heavy metals (Cu, Ni, Mn (Hanfi *et al.,* 2020). Vehicular pollution is very harmful amongst all other sources of pollution because it directly pollutes the air. It is detected through plants. Different aspects of heavy metal toxicity depend upon its dose, half-life and duration of exposure (Turkyilmaz *et al.,* 2020). Contaminants along the roadside and their order of toxicity are Cu>Ni>Mn. Symptoms of heavy metal toxicity were investigated as softness in tissues, vomiting, nausea, diarrhea and some reproductive problem, kidney, and liver ailments in living organism (Pandey and Madhuri, 2014). Sometimes it led to chronic diseases after long term exposure. Contamination gets into human body or animals through contaminated plants. Therefore, heavy metal impacts on food chain are prevalent because every single living organism depends on other for food. (Kumari and Mishra, 2021).

Maize (*Zea mays*) C_4 belongs to the family Poaceae is a cereal crop. It gets more importance because of highly cultivated in

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Pakistan after rice and wheat (Tariq and Iqbal, 2010) but its human directly usage decreased due to increasing production of maize as fodder and wet-milling industries 66% maize crop area has access to irrigation while remaining depend on rainwater. It is mostly cultivated in the spring season to get more yield (Tariq and Iqbal, 2010).

Developed countries have established threshold levels to control contamination but there are no standards for streets or roadside dust contamination through heavy metal (Aguilera *et al.,* 2021). Although in Pakistan there are some flexible standards so provided by APA Pakistan but there are hard and fast rules to follow to these standards therefore proper rules and regulations adopted to tangle this problem. Roadside automobile emissions and industrialization are the main sources of surface and groundwater contamination. It gets grave importance worldwide which is harmful to humans and other living organisms (Atangana and Oberholster, 2021). Urbanization and industrialization have led to an increase the roadside environmental degradation through metal pollution. Waste material in solid, liquid and gaseous form causes biological, chemical, and physical alteration in pure air which badly affects the living organism. Urbanization and industrialization are directly related to environmental degradation (Ali *et al.,* 2019).

Roadside metal contamination is increasing day by day, so it has become a nuisance at a global level. Roadside pollution is the main problem in developing countries because of unplanned urbanization and industrialization. Low budget, least resources and technology have become sources of roadside metal contamination in developing countries (Maeaba *et al.,* 2021). Vehicular emissions affect plant growth and development that is an alarming situation for the ecosystem. Toxic substances released from automobiles enter the water, soil, and air that adversely affect plant, animal, and human health. Copper and nickel released from vehicles negatively impact living organisms. which impacts on anatomy, physiology and morphology of plants (Altaf *et al.,* 2021). Some metals like Mn, Ni and Cu are essential nutrients for plants at lower level but cause toxicity when these elements exceed permissible limit. They play essential roles in metabolic activities especially in hemoglobin formation but when their concentration crosses the permissible limit. The permissible limit of copper set by FAO (1984) for edible plants is 3.00 µg g-1 or less, permissible limit of manganese set by FAO (1984) for edible plants is 2 µg g-1, permissible limit set by FAO (1984) for nickel in edible plants is 1.63 µg g-1 (Mekassa and Chandravanshi, 2015). Natural process of plants photosynthesis has been effected by toxicity of heavy metal (Kumar *et al.,* 2021). Manganese toxicity cause neurological, respiratory and digestion problems in adults (Rusydi *et al.,* 2021). Metal-contaminated Road dust causes chemical changes in the soil and affects the nutritional value of plants. Metal stressed plants have a great chance of pest attack that causes inhibition of plant growth and development (Kameswaran *et al.,* 2019). Metal contaminated dust particles stuck on leaves and cause altered stomatal action, decreased water potential, inhibition of respiration, and altered metabolism. Some particulate contaminants are absorbed in the soil and increase the soil pH. Heavy metals toxicity causes the shedding of leaves in plants. In severe cases, the death of tissues in plant leaves (chlorosis) has been observed (Sett, 2017). There by assessment of roadside contamination is a prerequisite to making proper policies and guidelines to avoid the dangerous impact of heavy metal pollution. Vehicular transport on road is the source of metal contamination. The objective of the survey study was to assess spatial pattern of heavy metal in roadside dust, soil, and plant. To measure the impact of these metals on maize crops near the roadside.

MATERIALS AND METHODS

Sampling site and sample collection

Faisalabad is known as Manchester of Pakistan due to textile industries and these industries have a big share in environmental pollution. Millat road (Faisalabad) is an avenue for other different roads which makes it a vulnerable source of metal contamination. Sampling was done at 17-7-2019 in summer season. To determine metal contamination (Mn, Cu, Ni) following the standards plants sampling procedure, the whole plant (above ground part) it about to 40-45 days old had no grains was cut and dried. Cut into pieces and grinded to fine powder then digested in acid mixture, dust and soil were collected from the cultivated area (Maize) near Millat road. For dust collection spread plastic sheet near the road in the early morning and collected it in the evening with help of brush and plastic pan from the sites and stored in polyethylene bag. Soil samples were collected in zipper bag with soil measuring instrument (augur) to maintain accuracy and errors. Soil texture was assessed by soil texture operators and soil structure was clay loam. Distance of the sampling site from the road was 10m, 30m and 60m. The distance between sites was five kilometers. Vehicular densities were also recorded by counting the vehicles at each site. Samples (plant, dust, soil) were collected with the help of a plastic pan (Johnson *et al.,* 2019). The samples collected from each site were labeled properly. Data for plant height was recorded by measuring any available three plants' height and averaged. With the help of the SPAD meter, chlorophyll contents were also recorded.

Storage

Plant samples were stored in a paper envelopes Plant fresh weight was recorded and left the samples for air drying. Soil samples were stored in a zipper bag and dust samples stored in polyethylene bag. Unwanted materials were removed with the help of a strainer.

Sample digestion

Di acid (HNO_3+$HClO_4$) is used for the digestion of plant samples. In order to digest the samples dried in the oven, 0.5g of dried plant samples and 6mL of concentrated HNO_3 were put into the flask and kept overnight. Then add 3ml $HClO_4$ to it and place it on the hot plate. Heat slightly for the first time, then intensely until white smoke was observed. These make the solution colorless. The sample was dropped from the hot plate. After waiting for five minutes, add 4-5mL of distilled water to it. The digested plant samples was crossed from the filter paper after cooling. The extract was collected in a 50ml volumetric flask, and distilled water was added to make the volume up to 50ml.

For the digestion of dust samples, the aqua regia method was used to prepare the samples (Hseu *et al.,* 2002). For digestion, use aqua regia to prepare dust samples and analyze the concentration of copper, manganese, and nickel in the dust on the road site. The ratio of the aqua regia mixture was 1:3 (HNO_3: HCl). Collect a dust sample (0.5g) in a 100mL Pyrex digestion bottle. Take out 20mL of the aqua regia mixture in the digestion tube. Leave for 24 hours for digestion. After the next day, the dust samples were digested on the hot plate until the temperature was high (250ºC). The condensed dust vapor was flying away. The sample were changed on the hot plate and it takes time to cool the dust sample. Then add 2-2mL of hydrogen peroxide to each sample to make the sample white. To further analyze the dust particles, the sample is diluted and prepared. After the instrument was standardized, the prepared samples were run on an atomic absorption spectrophotometer for the analysis of Cu, Mn and Ni. For digestion of soil samples, the AB-DTPA method was used for basic analysis and bioavailability of Cu, Mn and Ni. It is done by using an atomic absorption spectrophotometer. For this method, dissolve DTPA (1.97g) in pure water (800ml). To dissolve it, 2ml of NH_4OH was added to it. When DPTA became a solution form, NH_4HCO_3 (79.06g) was added to the solution and gently stirred. Then get the final volume of 1L.

RESULTS

Variation in plant growth and physiology of roadside plants

Data about plant height proved that minimum height was recorded in samples taken at 10m distance from road as compared to 30m and 60m from the road. Plant height ranged at 10m was 44-68cm. Maximum and minimum plant height noticed at the roadside cultivated crop was 68cm and 44cm respectively. While plant height ranged 61-72cm at 30m and 53-77cm at 60sm from the road. Data about plant height is mentioned in Figure 1. Fertilizer was applied on maize @ 60-90 kg/ha nitrogen and 60 kg/ha phosphorus.

Results indicated that dust harmed leaves. Dust quantity is directly proportional to the rush of transport on road and it directly affects soil health and plant growth (Kameswaran and Muralidhar, 2019). SPAD value indicates that maximum chlorophyll contents were 38.8 and minimum were 35.5 along the road at 10m distance. In contrast at 40.8-47.2 to 45.2-48.4 at 30m and 60m distance from road respectively. The data about SPAD value (chlorophyll contents) is documented in Figure 2. With the help of the SPAD meter, chlorophyll content was measured from randomly selected three plants. It indicated that the SPAD value increased with increasing distance from the road. In the contaminated area, dust particles are stuck on leaves and impact chlorophyll contents. Photosynthesis was also affected by decreasing chlorophyll contents in plants. It caused chlorosis in plants which hurt growth parameters due to a decrease in leaf nutrition levels (Sett, 2017). The effects of metal contamination on roadside maize were more severe at 10m than 30m and 60m distance from the road that can be observed by shoot fresh weight Figure 3.

The effect of increasing metal contamination on shoot fresh weight was severe. Contamination reduced fresh weight in maize more at 10m compared to 30m and 60m. Maximum decrease was observed in maize crop fresh weight was 35.42mg kg^{-1} and maximum increase in fresh weight 141.52mg kg^{-1} was observed. At 30m maximum decrease and increase in fresh weight was observed 46.27-178.12mg kg^{-1} following 60m maximum increase and the decrease was observed 272.71-97.8mg kg^{-1}. Results revealed that noxious emissions from vehicles, anthropogenic and industrial activities had significantly enhanced metal concentration in plants and soil along the roadside. This was confirmedby previous researchers Romdhane *et al.* (2021) absorption of heavy metal from the environment (Vehicles emissions, anthropogenic and industrial sources) as predominant as migration of metal concentration from soil to plants body. Effluent and sludge from dumpsite are the sources to increase the metal concentration in soil which increase soil pH and electrical conductivity which effect on soil fertility, plant growth and physiology of plant along the roadside. Like the shoot fresh weight, metal contamination on shoot dry weight was also severe Figure 4. Reduction in shoot dry weight was observed at 10m (12.88-26.92mg kg^{-1}) following 30m (4.52-41.66mg kg^{-1}) and 60m (8.23-37.52mg kg^{-1}) respectively.

Variation in copper concentration in dust, soil, and plant

Variation in concentration of Cu in dust, soil and plant samples were shown in (Table 1). Cu concentration was higher in soil samples as compared to plant and dust samples.The results revealed thatthe maximum concentration of Cu (40.1Mg kg^{-1}) in soil was measured at 10m along the roadside. The concentration of copper in dust was 11.03mg kg^{-1} and inthe maize crop was 11.18mg kg^{-1} that is almost similar at 10m along the roadside. Researcher Romdhane *et. al.* (2021) depict that copper concentration in soil was increased due to anthropogenic, industrial activities, atmospheric deposition and mine tailings. The use of copper-based fungicide, sewage sludge and animal manure increases the concentration of copper in the soil. Copper contaminated dust stuck on leaves causesa decrease in chlorophyll contents, decrease the photosynthetic rate and cell elongation.

Variation in manganese concentration indust, soil and maize

Variation in Mn concentration of dust, soil and plants as shown in (Table 1). Manganese concentration in soil was approximately equal to Mn concentration in the dust.Mn concentration in soil (max=189.66mg kg^{-1}, mini=156mg kg^{-1}) and dust (max=179.7mg kg^{-1}, mini=171.75 mg kg^{-1}) at 10m distance from roadside was recorded. Manganese is used in steel, dyes, pigments, batteries, anthropogenic activities and steel utensils. Industrial waste which is discharged from different industries affects soil fertility and increases the dust accumulation on plants. This accumulated dust contaminated with Mn slowdown or sometimes stop the process of photosynthesis which results in a reduction of shoot fresh weight and dry weight. Dust contaminated with Mn when fall on soil is very harmful to all living organisms because Mn is adsorbed by soil and it is uptake by plants that enter into the food chain.

Table 1. Spatial variation in metals (Cu, Mn, Ni) concentration in soil, dust, and maize

	Soil			**Dust**			**Maize**		
Cu (mg kg^{-1})	10m	30m	60m	10m	30m	60m	10m	30m	60m
Site 1	32.23^{c}	22.26^{def}	20.9^{efg}	11.03^{a}	5.82^{f}	1.90^{g}	9.26^{bc}	1.87^{de}	1.58^{de}
Site 2	40.1^{a}	21.13^{efg}	17.13^{h}	10.03^{ab}	8.25^{cd}	1.85^{g}	8.53^{bc}	1.88^{de}	1.72^{de}
Site 3	36.6^{b}	23.3^{de}	19.1^{gh}	9.14^{bc}	6.55^{ef}	8.27^{cd}	10.14^{ab}	8.27^{c}	2.52^{d}
Site 4	38.3^{ab}	24.06^{d}	20.53^{fg}	9.07^{bc}	7.30^{de}	2.71^{g}	11.18^{a}	2.54^{d}	0.46^{e}
Mn (mg kg^{-1})									
Site 1	189.66^{a}	160.2^{d}	125.06^{f}	171.75^{c}	136.12^{e}	15.82^{j}	15.3^{d}	12.6^{e}	11.31^{f}
Site 2	166.06^{c}	99.13^{g}	89^{h}	179.7^{a}	160.36^{d}	85.26^{h}	17.56^{c}	17.56^{c}	8.10^{g}
Site 3	156d	157^{d}	95.3^{g}	175.3^{bc}	177.20^{ab}	111.45^{g}	20.75^{b}	13.46^{e}	10.51^{f}
Site 4	176.73^{b}	180.76^{b}	133.13^{e}	177^{ab}	123.23^{f}	49.2i	23.01^{a}	18.2^{c}	21.16^{b}
Ni (mg kg^{-1})									
Site 1	3.33^{de}	1.56^{gh}	1.56^{gh}	7.62^{ab}	3.63^{d}	2.62^{de}	3.75^{a}	3.9^{a}	0.86^{ef}
Site 2	5.6^{a}	3.16^{def}	2.5^{efg}	9.37^{a}	9.28^{a}	4.56^{cd}	1.41^{de}	0.52^{f}	1.68^{bcd}
Site 3	4.5^{bc}	1.53^{h}	1.53^{h}	8.74^{a}	7.55^{ab}	6.31^{bc}	1.61^{bcde}	2.3^{bc}	0.41^{f}
Site 4	3.8^{cd}	4.96^{ab}	2.26^{fgh}	5.7^{bc}	3.46^{de}	1.55^{e}	1.5^{cde}	2.3^{b}	1.51^{bcde}

Values are presented as means of three replicates ± SD, means sharing similar superscript letters within column are statistically non-significant according to HSD Tukey test at $p<0.05$ Maize (above ground part) was taken for sampling.

Variation in Nickle concentration of dust, soil and maize

Variation in concentration of Ni in soil, dust and plant samples was shown in (Table 1). Ni concentration in the dust sample was observed in higher concentration at 10m as a comparison to 30m and 60m. Ni concentration in soil samples was associated with Ni concentration in plants. Nickle concentration ranges 5.1 to 9.12 mg kg^{-1} in dust, 3.4 to 5.5mg kg^{-1} in soil and 1.5 to 3.85mg kg^{-1} in plant samples at a 10m distance from the road. It declared from the results that there was a high concentration of Ni near the sources that decreased with increasing distance fromthe contamination source.

DISCUSSION

A survey study was conducted to examine the effect of three heavy metals at three distances 10m, 30m, and 60m from the road. Millat Road (15 link road) is an important gateway to the dry port and Sargodha highway. The intensive traffic and industrial activities close to the roadside make it an area prone to metal pollution. Amer food industrie, Karss paint industries and some other industries are worikng on small level in research area. These are in cultivated area of research and some are away from the road but their wastage have assess to the cultivated areas.These heavy metals (Cu, Mn, Ni) present in plants, soil and dust alongthe roadside (Millat road) Faisalabad, Pakistan influence plant growth and physiology (fresh weight, dry weight, chlorophyll content). Plants (maize) accumulate Cu, Ni and Mn in high concentration near to roadside that is vehicles pollution source. The increasing rate of these heavy metals in soil and plant suppressed the plant growth, plant fresh weight andplant dry weight.Metal contamination is injurious to other living organisms. However, reduction in growth, fresh weight, dry weight and chlorophyll contents was more prominent at 10m from the roadside. Bahiru, (2021) observed that metal contamination significantly reduces the quality of food products. When these productsare used by living organisms they result in Carcinogenic and neurotoxin effects on human health. In this way, metal contamination joins the food chain and negative impact on a living organism. Heavy metal contamination gets special attention due to its toxic effects on plants and other living organisms. Barua and Abdullah, (2021) noticed that decline in biomass, growth and change in the physiology of plants is due to an increase inthe concentration of heavy metals (Cu,Ni, Mn). Metal contamination also stunts the shoot and root growth and may cause homeostasis. These metals cause softness in tissue which degrade plant growth and physiology. It transfers easily to a living organism (animals and humans). Vardhan *et al*. (2019) reported that essential and non-essential elements present in the soil may be harmful at over the limit, depending on the nature of plant species and soil. These metals significantly influence the electrical conductivity and pH of soil however contaminated soil is considered an avenue to plant toxicity. Plants grown on contaminated soil have a high level of toxic metal and it is very injurious for all living organisms that have direct access to these contaminated plants. Results of the survey study elucidated that Contamination increasing with decreasing distance from road (10m) and decrease with increasing distance from road (30m, 60m). It is because of the damaging effects of roadside contamination sources like the exhaust of noxious gases from vehicles and other sources of contamination as anthropogenic activities. The contamination concentration of plants depends on the density of traffic on road. Plant growth parameters are good in rural areas as compared to urban areas because contamination depends on the availability of contamination sources along the roadside (Sevik *et al.,* 2020). A significant effect of metal accumulation on growth and physiology was observed at 10m from the road. According to Negahban and Mokarram (2021). Maximum concentration (2.5 mg/kg) of heavy metal was recorded near roadside because anthropogenic activities increase the accumulation of naturally occurring heavy metal in soil. Contamination sources increase near the roadside because of brake lining, fuel combustion and tire wear.

Maize (*Zea mays*) is C_4 plant belong to family poaceae.It is main crop which is mostly cultivated as a cereal in Pakistan after rice and wheat.It annual production is 2,850 kg/ha approximetly. After the increasing maize production as fooder and wet milling industries, human directly consuming proportion of maize is decreased 66% maize cultivation in mostly spring season has access to irrigation water while other depend on rain water. Contamination of metal on maize was assessed based onnegative impact on plant height (Table 1 and Figure 1) and heavy metals (Ni, Cu, Mn) accumulation. It is due to the use of private vehicles. Hazardous particles emitted from automobiles can cause air pollution which is stuck on the leaves of plants in form of dust. Automobiles are the main source of contamination. The nature of aerial pollutants may be gaseous and particulate. Gaseous particles are stuck on the leaves of plants and cause the closing of stomata, reduction in photosynthesis which negatively impacts on fresh and dry biomass of plants. Particulate particle absorbed in the soil and causes soil contamination which declines soil pH (Muthu *et al*., 2021). Zhang *et al.* (2019) depicted that cultivation of green belt hasa great quality of the product as a comparison to urban areas and developing part of the community because in a rural area less availability of transport as compared to urban roads. The finding of the survey study demonstrated that Cu concentration in soil was found higher as compared to the concentration in dust and plants. It may be due to the accessive use of metal-containing fertilizers, fungicides and pesticides that contaminate soil and plants which ultimately cause cytotoxicity and leaf chlorosis. When this contaminated food entered human's, animals bodies cause serious problems (Kumar *et* a*l.,* 2021). Our finding regarding metal accumulation proved thata high concentration of Ni impacts chlorophyll content because Ni plays a vital role in the physiological process. Its toxicity causes reduction in photosynthesis, decrease the chlorophyll contents and affect other parameters like deficiency of water contents in leaf (Fiala *et al.*, 2021). It may be due to human activities like extra use of fungicides, pesticides and insecticides cause toxicity ofthe soil. Automobile dust and toxic gasses stuck on leaves that block the stomata, inhibit the photosynthetic rate and result in a reduction of chlorophyll contents (Shafique *et al*., 2021).

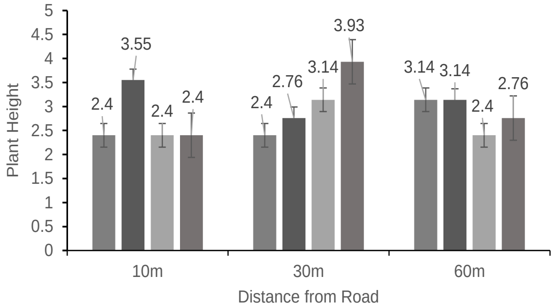

Figure 1. Variation in plant height with distance at Millat Road Faisalabad. Data are the average of three replications (± SD). The values sharing different letter (s) are statistically significant at *P*≤ 0.05.

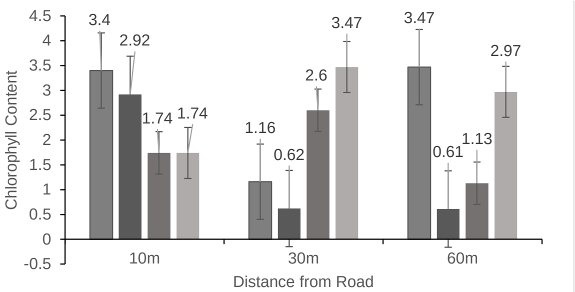

Figure 2. Variation in SPAD value with distance at Millat road, Faisalabad. Data are the average of three replications (± SD). The values sharing different letter (s) are statistically significant at *P*≤ 0.05.

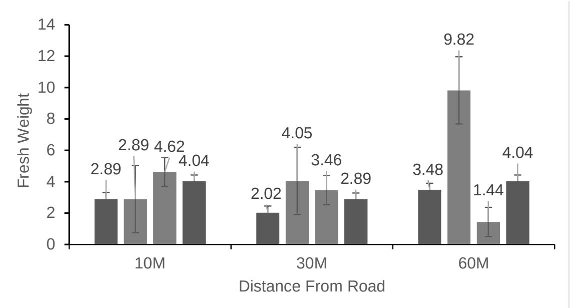

Figure 3. Variation in shoot fresh weight with distance at Millat road, Faisalabad. Data are the average of three replications (± SD). The values sharing different letter (s) are statistically significant at *P*≤ 0.05.

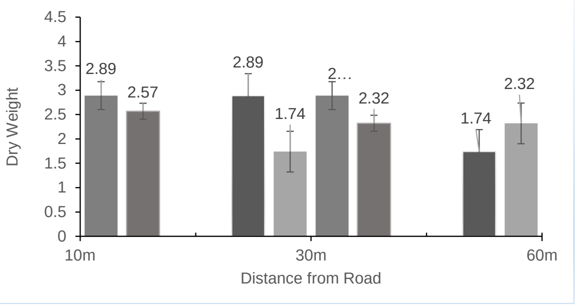

Figure 4. Variation in shoot dry weight with distance at Millat road, Faisalabad. Data are the average of three replications (± SD). The values sharing different letter (s) are statistically significant at *P*≤ 0.05.

CONCLUSION

A survey study was initiated to assessing heavy metal contamination impact in maize growing on the roadside. Dust, soil and maize samples were collected from four sites and Cu, Ni and Mn concentrations were analyzed through a standard protocol. As result, metal concentration in soil, dust and maize decreased with increasing distance from the road (*P*≥5). Samples collected at 10m were found a higher concentration of heavy metal as compared to 30m and 60m distance from the road. As revealed by the results copper concentration in soil was found in higher concentration as compared to dust and maize. Manganese concentration was found equal in dust and soil samples as compared to maize. Nickel concentration was found higher in maize and soil as compared to dust. The results obtained from this survey study elaborate that should take action about vehicles noxious emission, anthropogenic activities and industrialization to control the environmental degradation. Depletion of natural resources through metal contamination causes pollution and human health issues. Achievements directly from the Industrial Revolution are only catastrophic to the world environment. These identify the environmental consequences of industrial growth and provide recommendations to prevent environmental degradation, including use clean technologies and environmentally sound production technologies, especially for developing countries like Pakistan (Ahuti, 2015).

AUTHOR’S CONTRIBUTION

F. Malik: Designed, conducted the research and wrote manuscript.

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