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LEAD CONTENT IN SOIL AND WHEAT TISSUE ALONG ROADS WITH DIFFERENT TRAFFIC LOADS IN RAWALPINDI DISTRICT

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Abstract

A field study was conducted to evaluate the lead contents in soil and wheat as affected by vehicle exhausts in Rawalpindi district (Rawalpindi, Attock and Fatehjang). For this purpose three different traffic roads varying in traffic densities viz., Pir Vidhai road, Kamra road and Fatehjang road were selected. On each road five different fields at a distance of 20, 220, 420, 620 and 820 meters across the road were selected. Wheat crop was sown in September and October, 2003. All cultural and management practices were those of farmers of the area. Plant and soil samples were collected at flag leaf stage. The plant samples were digested in nitroperchloric acid mixture and soil samples were collected before and after experiment were extracted with Ammonium bicarbonate-diethylene triamine pentaacetic acid (AB-DTPA) and lead content was determined by atomic absorption spectrophotometer. The data were statistically analyzed using regression model. Lead contents of both soil and plant samples were positively correlated with the traffic density and negatively correlated to distance from the road. The lead contents in soil and plants at Pir Vadhai Road (the busiest road) were found to be highest. Least contents of Lead were found in the soil and plant samples along Fatehjang road (medium traffic load. Along Kamra road (having the lowest traffic load), maximum values of Lead contents at 620 and 820 m distance in the soil and plant samples were attributed to use of Sewage water.

Introduction

Environmental pollution has become a worldwide concern as it may adversely affect human health. All the three spheres viz., atmosphere, hydrosphere and lithosphere are being polluted by different sources. The atmospheric pollution is caused by release of gases from industries, burning of fossil fuels and vehicle exhaust. The vehicle exhaust in addition to the toxic gases also contains heavy metals and lead (Pb) being the prominent one. Lead in automobile exhaust is mainly in the form of halide salts. Exhaust Pb particles are unstable and readily convert into oxides, carbonates and sulfates.

Lead is the heaviest of the non radioactive metals that also naturally occurs in substantial quantities in the earth's surface. It is present in all soils, rivers, lakes and sea water. It is also a component of dust, rubber, paints, solder, metal products (steel & brass) and lead batteries. Lead enters the body from air during breathing but most of it is taken in orally, where it becomes a component of food, beverages, drugs, supplements and almost any thing else that is ingested. The main health problems associated with chronic high levels of Pb in blood are neurological impairment in children and hypertension in adults. Pregnant women must be specially cautious about lead exposure, both because of increased risk of spontaneous abortion and potential damage to the fetus, which may occur with maternal blood levels of 10 µg/l or more (Dharmananda, 2001).

Plants absorb Pb through soil, water and air. Besides the uptake from the root and the water, Pb may enter the plant surface through aerial parts including the leaf surface. Plant

growth is very sensitive to Pb which is present in the root-medium. High concentration of Pb may lead to the reduction in the root hair development and stunted growth due to reduced photosynthetic rate in plants, as a result of induced closure of the stomata by the deposition of Pb (Sarkar & Jana, 1986).

Lead first enters the food supplies in significant quantities by contamination of soil and lead dust accumulating on the plants. Lead is taken up by the plants through roots and leaves. The plant materials are eaten up by humans and animals and in this way lead enters the body. The plant foods tend to have higher lead levels than animal foods because plant can absorb and retain more lead than animals. Lead from atmosphere that falls on soil has low mobility and tends to stay in the top layer of soil. Therefore, shallow rooted plants such as grasses and common vegetables are particularly vulnerable to lead contamination that originates in the atmosphere.

In soils the natural Pb contents are strongly related to the composition of the bedrock, and it is reported to be the least mobile among the other heavy metals. The relatively low Pb concentrations in natural soil solutions support this statement. Although the Pb species can vary considerably from one soil type to another, it may be concluded that Pb is associated mainly with clay. The study was planned with the objective to evaluate the Pb contamination of soil and the wheat crop caused by vehicle exhaust at various distances away from the main road.

Materials and Methods

The study was conducted on the farmer's fields in the Rawalpindi District during Rabi 2003-2004. For this, three roads viz.1); Pir Vadhai Road (High traffic load); 2) Fateh Jang Road (medium traffic load); and 3) Kamra Road (low traffic load) were selected. On each road, three adjacent fields at a distance of 20 m, 220 m, 420 m, 620 m and 820 m were selected. Wheat cultivar Wafaq, 2000 was sown in September, 2003. Recommended fertilizer doses of Nitrogen and Phosphorus were applied in the form of Urea and DAP. The soil texture and pH of the experimental fields on the three roads are given in Table 1.

Table 1. Soil texture and pH of experimental sites.

Distance (m)	Soil Properties	Pir Vadhai Road	Fateh Jang Road	Kamra Road
20	Soil texture	Sandy loam	Sandy loam	Sandy
	pHs	8.4	7.5	7.3
220	Soil texture	Sandy loam	Sandy loam	Sandy
	pHs	8.2	7.3	7.3
420	Soil texture	Sandy loam	Sandy loam	Sandy
	pHs	8.3	7.3	7.3
620	Soil texture	Sandy loam	Sandy loam	Sandy loam
	pHs	8.4	7.4	8.6
820	Soil texture	Sandy loam	Sandy loam	Sandy loam
	pHs	8.0	7.4	8.7

Plant and soil samples were collected from experimental fields when the crop was at flag leaf stage. Soil samples were collected from 0-30cm depth and were analyzed for Soil texture by Hydrometer method (Bouyoucos, 1962), pH of saturated soil paste by using pH meter having combination electrode and Ammonium bicarbonate-diethylene triamine pentaacetic acid (AB-DTPA) extractable Lead (Soltanpour & Worksmann, 1979). Plant samples were digested in nitroperchloric acid mixture and Lead was determined by Atomic Absorption Spectrophotometer. The data was subjected to Regression Analysis by the method described by Steel & Torrie (1984).

Results and Discussion

Pir Vadhai is one of the busiest roads of Rawalpindi, having a high traffic load. The farmers are growing wheat crop on many fields nearby the road. The average number of vehicles that pass on this road at peak hours is approximately 1100-1200 per hr. The data showed that the lead content of wheat leaves decreased as the distance across the road increased from 20 to 820 meter. The mean values of the Pb in the plant samples were found to be 32.59, 28.10, 13.35, 5.40 and 2.45 mg kg^{-1} in the fields at a distance of 20, 220, 420, 620 and 820 m across the road respectively (Fig. 1). The statistical analysis showed R^2 = that 92.1% Pb pollution in plant samples was due to the vehicle exhaust and the remaining was due to other factors. The slope value showed that on the average at every 200 m across the Pir Vadhai road, the value of Pb decreased by a factor of -0.04.

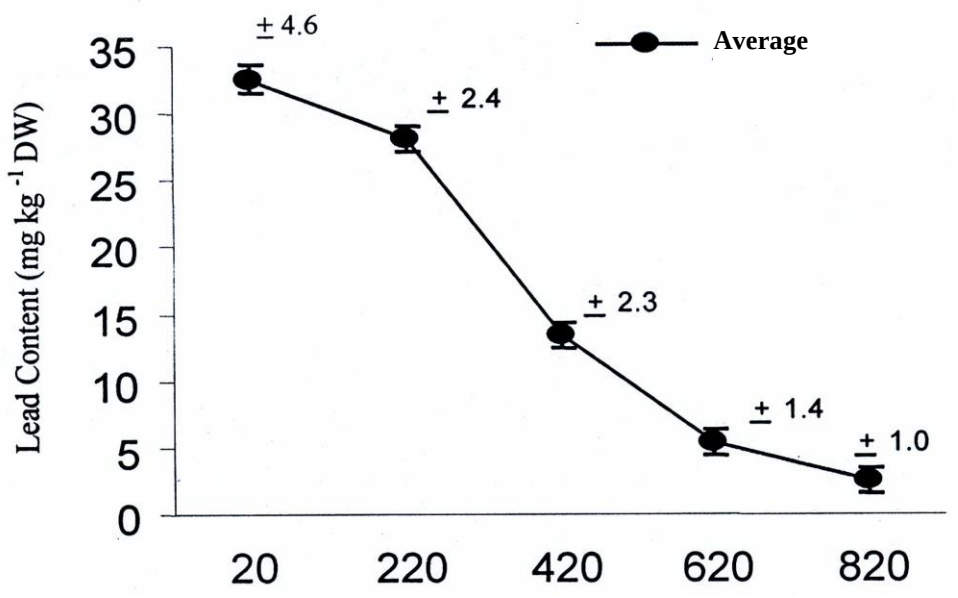

Fig. 1. Lead content of Wheat leaves across Pir Vadhai Road.

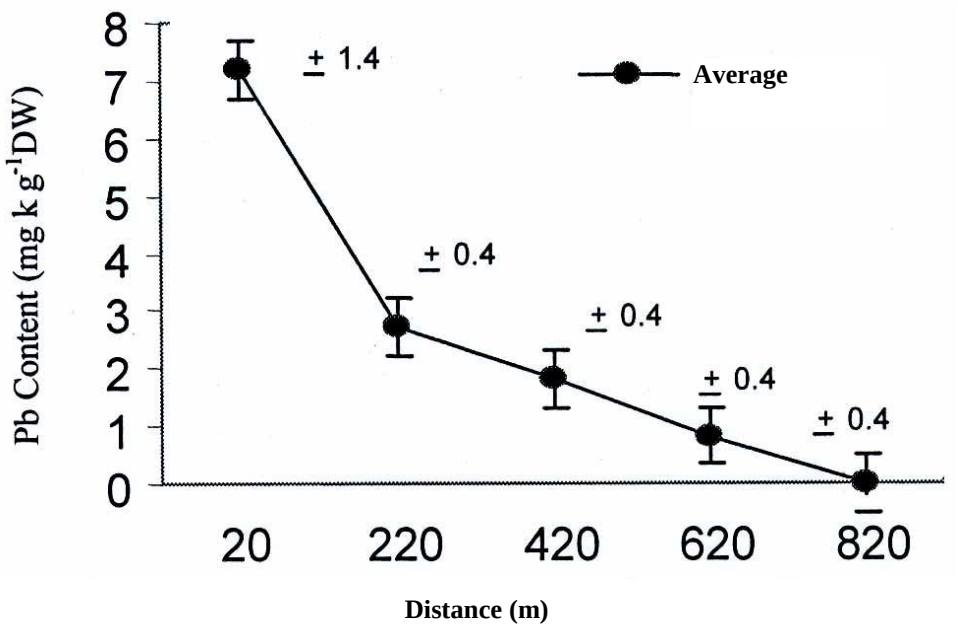

Fig. 2. Lead content of wheat leaves across Fatehjang Road.

Fatehjang road is not as busy as Pir Vadhai road in Rawalpindi area. The numbers of vehicles which pass on this road during peak hours have been estimated 500-600. The data showed that Pb content in wheat leaves decreased with increase in distance across the road (Fig. 2). The mean values of the Pb in the plant samples were found to be 7.24, 2.71, 1.23, 0.00 mg kg^{-1} in the fields at a distance of 20, 220, 420, 620 and 820 m across the road respectively. The statistical analysis showed R^2 = 0.7957 indicating that 79% variation was due to the vehicle exhaust. The Pb accumulation in plant samples was negatively correlated with the distance from the road. If we go away from the Fatehjang road, on the average the value of the Pb was decreased by –97.05.Sun & Zaho (1997) found that along with the absorption of the Pb from the soil the plants also take this heavy metal through their aerial parts.

The traffic density on the Kamra road is very low (vehicles 200-250). The data showed that lead content in wheat leaves decreased with increase in distance from 20 m to 420 m distance across the road (Fig. 3). Beyond that it increased significantly at the distance of 620 m and then again decreased. The mean values of Pb in the plant samples were found to be 9.30, 3.41, 2.37, 16.40 and 13.85 mg kg^{-1} in the fields at a distance of 20, 220, 420, 620 and 820 m across the road respectively. The regression value (0.306) indicates that about 70% of the pollution at this site was due to the other factors. Slope value indicated a positive relation with that of the distance. The significant increase in lead contents at a distance of 620 m was unusual because of application of sewage water by the farmers in this field. It has been observed previously that the sewage applied to vegetables in Rawalpindi area contains lead in quite high concentration that increased lead contents in plants (Saleem, 2001).

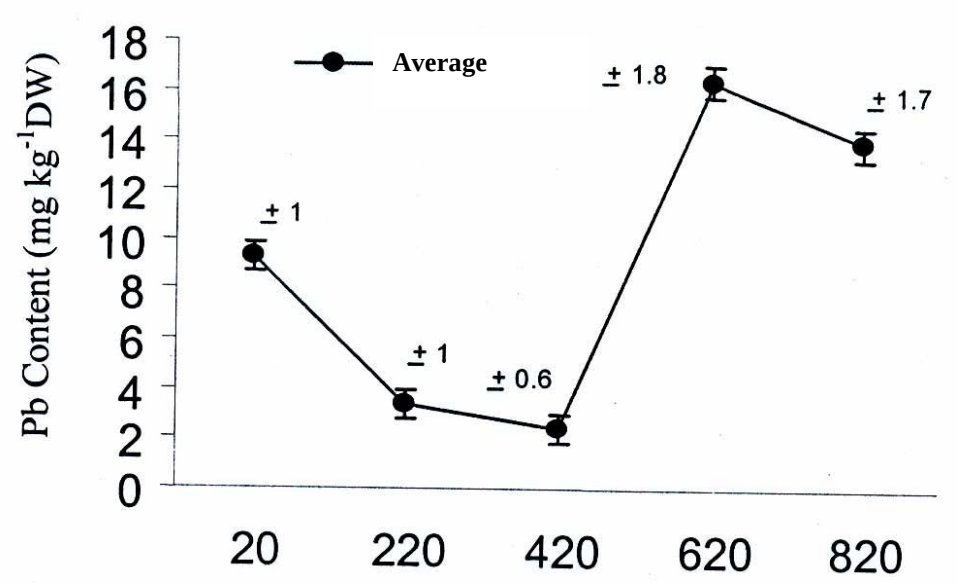

Fig. 3. Lead content of wheat leaves across Kamra Road.

The comparison of the lead values at different distances on three roads showed that at the fields located across Pir Vadhi road had higher contents as compared to Fatehjang and kamra road. At all distances it was in the order Pir Vadhai > Kamra >Fatehjang except at a distance of 620 and 820 m where it was in the order Kamra>Pir Vadhai> Fatehjang because of the use of Sewage and FYM application. Higher contents of the Pb in the plants of Kamra were found as compared to the other two sites. Ferguson, 1990 also observed that Pb contamination by traffic can move to the tissues of the plants and go with food chain.

The data on Lead content of experimental fields at different distances across the three roads is given in Figs. 4, 5, 6 and Table 1. The mean values of the Pb in the soil samples at a depth of 0-30 cm across Pir Vidhi road was found to be 23.46, 14.94, 8.05, 3.23, and 0.57 mg kg^{-1} at a distance of 20, 220, 420, 620, and the 820 m respectively (Fig. 4.). The statistical analysis showed a regression value of 0.937 indicating that 93.7% variation was due to vehicle exhaust. Pb accumulation was highly dependent upon the distance from the road. The traffic density and the accumulation of Pb had a positive relationship to Pb accumulation, while distance and the Pb accumulation had inverse relation to each other.

Similar trend was observed across Fatehjang road where the mean values of the Pb in the soil samples were 5.72, 3.87, 0.88, 0.70, 0.00 mg kg^{-1} at a distance of 20, 220, 420, 620 and 820 m respectively (Fig. 5). The statistical analysis showed R^2 = 0.7771 indicating that 77.7% lead accumulation was due to the vehicle exhaust. If we go across a distance of 200 m from the Fatehjang road the value of the Pb decreased by a factor of -106.

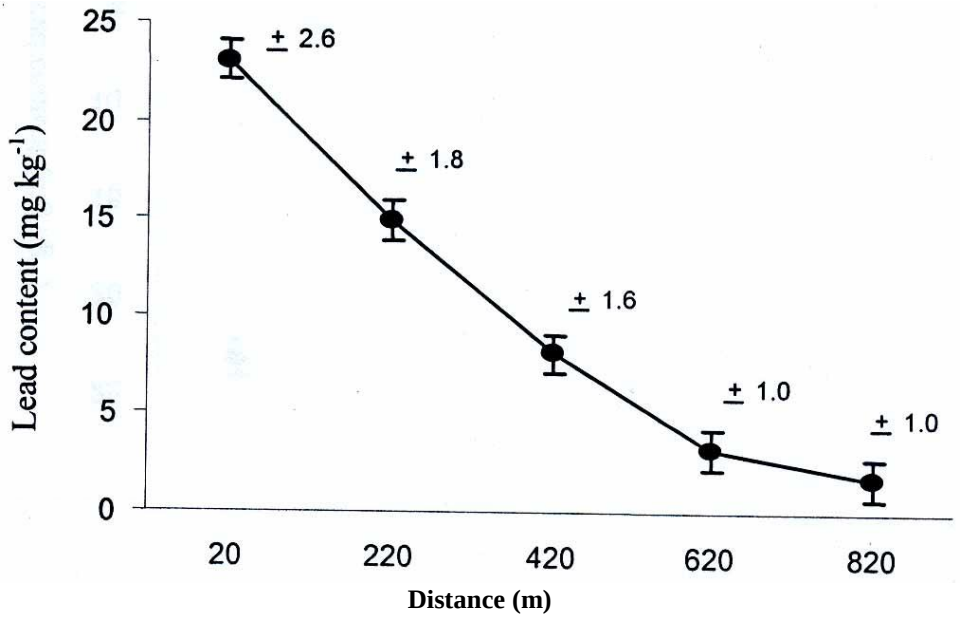

Fig. 4. Available Pb content of soil across Pir Vadhai Road.

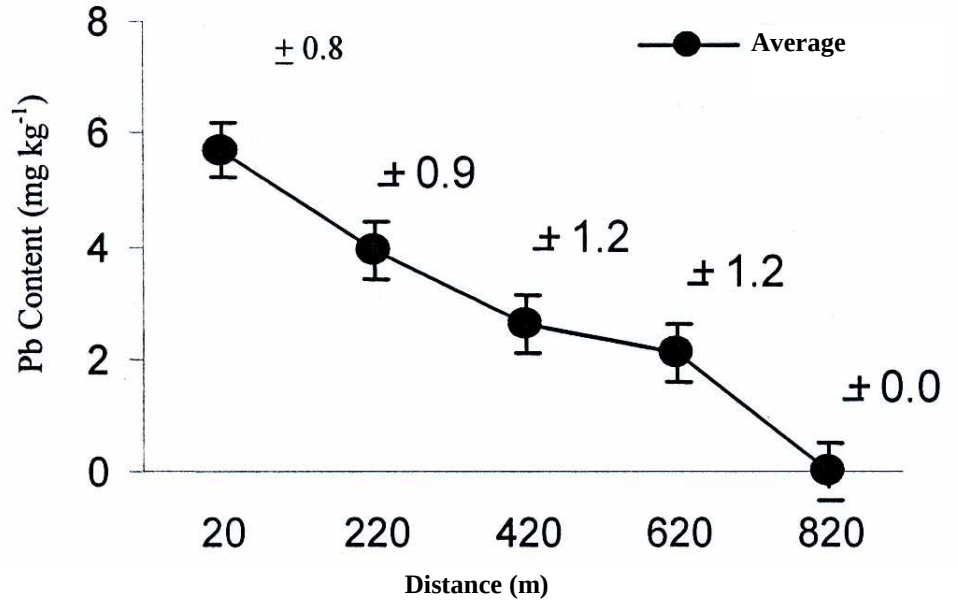

Fig. 5. Available Pb content of soil across Fatehjang Road.

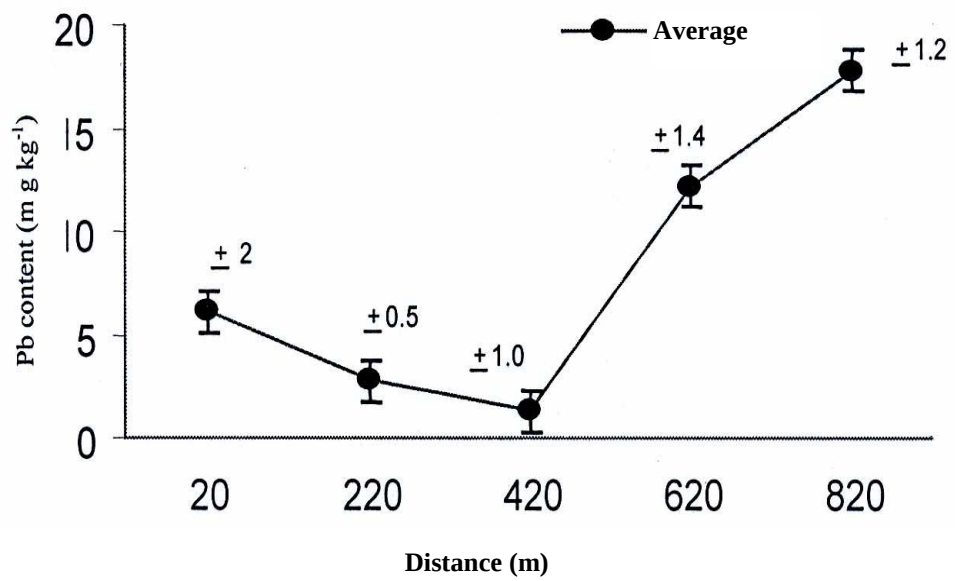

Fig. 6. Available Pb content of soil across Kamra Road.

Along Kamra road, the mean values of the Pb in the soil samples were found to be 6.10, 2.78, 1.25, 12.24 and 17.76 mg kg^{-1} at a distance of 20, 220, 420, 620 and 820 m respectively (Fig. 6). The data showed that the highest value of Pb accumulation was found at 820 m distance followed by 620 m (17.76 and 12.24 mg kg^{-1}). The regression value of the data was 0.548 indicated that only 54% of Pb pollution was due to the vehicle exhaust and 46% was due to the other factors. The statistical analysis also showed that as the distance increased the value of the Pb increased. This unusual result was due to the application of the sewage water to the soils. Rashid (1986) in nutrient mapping during survey of Pothwar area found that Zn translocation is directly proportional to Zn contents in the soil. This has proven that emission of lead along the road side increased Pb contents and affected crop uptake. Moreover, sewage contains high contents of Pb because of the source of its emission.

The data showed that Lead content of soil samples decreased with increase in distance on all roads except at Kamra where it increased at a distance of 620 and 820 m, which could be attributed to application of sewage and FYM.

The highest mean value was recorded in the Kamra followed by the Pir Vadhai and the Fatehjang. Higher contents of Pb at Kamra were due to the reason that the farmers were using sewage water in these fields for the crops. The soils of the Fatehjang showed lesser quantity of the Pb accumulation because of less traffic density, vegetation along the roads and sandy loam texture of soil. These results are in line with that of the Agrawal (1999) who found similar results for Pb accumulation in the soil, leaves and bark of the *Mitragyna perviflora* at different distances from the road. Accumulation of higher Lead contents in grasses has been reported in New Orleans area (Dharmananda, 2001)

References

Agarwal, S.K. 1999. *Studies on the effect of the auto exhaust emission on the Mitragyna patriflora*. M. Phil thesis. M. D. S. University. Ajmeer.

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle size analysis. *J. Agron*., 53: 464-465.

Dharmananda, S. 2001. Director, Institute of Traditional medicine, Portland, Oregon. http:/www.itmonline.org/arts/lead.html.

Ferguson, J.E. 1990. *The heavy elements; Chem. Environmental impact and the health effects*. Pergamon press. London, U. K.

Rashid, A.1986. *Mapping Zinc fertility of the soils using the indicators plants and soil analyses*. Ph. D. Dissertation. University of Hawaii. H.I. U.S. A.

Saleem, S. 2001. *Heavy Metal Contents of Vegetables and Soil Irrigated by Different Quality Waters in Hassanabdal and Wah Cantt Area*. MSc (Hon's) Agri. Thesis. University of Arid Agric., Rawalpindi.

Sarkar, A and S. Jana. 1986. Heavy metal pollution tolerance. *Water Air and Soil Pollut*., 27: 15-18.

Soltanpour, P.N. and S. Worksmann. 1979. Modification of the $NaHCO_3$ DTPA soil test to omit common black. *Soil Sci. Plant Analysis*., 10: 1411-1420.

Steel, R.G.D. and J.H. Torrie. 1984. Principles and Procedures of Statistics, Mc Graw Hill Book Co., Inc. New York. 188-189.

Sun, Z.D. and Z. Zaho. 1997. Effect of Pb pollution of atmosphere on the soil and wheat growth. *China Agriculture University-lienensis*., 31: 141-144.

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