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STONE CRUSHING DUST AFFECTS THE YIELD AND QUALITY OF APRICOT FRUIT

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The present study was conducted during 2013 with the aim to evaluate the effects of stones crushing dust pollution on "Golden orange" Apricots (*Prunus armeniaca* L.) fruit Yield and quality. The experiment was carried out on *P. armeniaca* L. cultivated near the north-western (Brewery) bypass of Quetta. Plant materials (leaves and fruits) were collected from three polluted locations at a distance of 500, 1000 and 1500m, respectively away from the stones crushing plants and a location of relatively clean air considered a control at 4,000m away from these crushing plants. The deposit dust washed from the surface leaf area of plant studied was found to be 4.74, 3.65, 1.85 and 0.22µg/cm² at the four locations, respectively. The locations affected by more stone dust pollution (500m) were leading to a reduction in the yield and quality of fruits. The accumulation of dust pollutants to the loamy sandy soil of the present study altered soil chemical composition. Significant reductions have been observed in the biomass of fruits/tree, number of branches/tree and number of fruits/branch in polluted locations than those of the control sites. The results of the current study are also revealed that the stones dust decreases the proximate and essential elements constituents at a considerable level.
Keywords: *P. armeniaca* L, Proximate and elements constituents, Soil chemical composition, Yield and quality

INTRODUCTION

It is difficult to estimate the effects of air pollutants because the organisms are exposed to a wide range of uncontrolled variables (parasites, weather conditions, complex mixture of pollutants). Stone crushing dust is one of the most important pollutants in the environment which poses a threat to the proper functioning of crops in the vicinity of stones crushing units**.** On the morphological point of view, the plants from polluted sites present important changes especially regarding their colors, shapes, leaf length, width, area and petiole length (Leghari and Zaidi, 2013). The particulate dust falling on the leaves of plants put serious effect on photosynthesis, stomatal functioning, productivity, pigment and metabolic constituents and also causes foliar injuries. A significant reduction on plant length, cover, number of leaves and total chlorophyll contents for *Vitis vinifera* L. was also observed by Leghari *et al*. (2014) due to road side dust particulate matters. The particulate dust falling on the leaves of plants and soil not only caused the reduction in yield and uptake and accumulation of elements from soil beside its major effects on soil quality and fertility (Nanos and Ilias, 2007; Migahid and El-Darier, 1995; Lerman and Darley, 1975; Mishra, 1991). The soil surrounding cement and stone producing factories, especially downwind areas, exhibit elevated pH level (Adamson *et al.,* 1994; Mandre, 1997; Mandre *et al.,* 1998). In a soil composition, it was found that there were elevated levels of chromium, silica, iron, calcium and thallium with contamination level decreasing dramatically with distance from the factories. These compositions affect vegetative growth (Asubiojo *et al.,* 1991; Ade-Ademilua and Umebese, 2007). Proximate and nutrient analyses of edible plant and vegetables play a crucial role in assessing their nutritional significance (Pandey *et al*., 2006). Iqbal *et al.* (2014) reported that the mercury treatment produced toxic effect on seed germination, seedling growth and seedling dry weight of *Albizia lebbeck*. They also indicated that the increase in the concentration of mercury at 7 mM in the medium brought up different changes in the all growth parameter performance of *A. lebbeck*. Younis *et al.* (2015) studied the effect of particulate matter on biometric and biochemical attributes of two fruiting plants. They found that most of the biometric and biochemical parameters were affected by the dust accumulation. Plants are an integral part of life in many indigenous communities. A great attention has been given in developed countries about the effects of dust and metal toxicities on germination, growth of plant and their productivities. Stone dust and metal toxicity is an important factor governing germination of seeds, growth and productivity of plants. Therefore, the main objective of the study was to determine the effect of stone dust on yield and quality of an important tree *P. armeniaca* L. and its soil characteristic which is commonly known as Apricot fruit

(Golden Orange). It is commonly grown in Balochistan, Pakistan.

MATERIALS AND METHODS

Leaf and fruit samples collection and treatment**:** The study area was located near northwestern (Brewery) bypass in the Quetta, Balochistan Pakistan. Four orchards of *P. armeniaca* L. were selected at four different locations downwind from stone crushing units in the study area. The three locations were at a distance of about 500-550, 1000-1100 and 1500-1600m, respectively away from the stones crushing plants and the fourth location of relatively clean air considered a control at 4,000-5000m away from these crushing units where the stone dust load was nearly zero. Randomly 15 trees were selected in each location as accounting the number of branches in each tree and the number of fruits in each branch. Mature fruit samples were collected at maturity stage in summer from random trees approximately at the same age. The fruits were separated from weeds and dirt, washed and rinsed with distilled water. It was sun-dried for 5 days, ground in a mortar with a pestle into coarse power and packed in an air-tight plastic container for further analysis.

Proximate analysis of fruit samples**:** Proximate composition of the *P. armeniaca* L. fruits was carried out in accordance with Association of Official Analytical Chemists (A.O.A.C) methods (1990). Proximate composition of a substance constitutes the different classes of nutrients present in the samples such as carbohydrates, protein, fat, crude fibre, and caloric value (energy) calculated from values of carbohydrate, fat and protein. All the methods used in estimating the chemical composition of the fruit samples were standard methods of the Association of Official Analytical Chemists (1990) except where otherwise stated. The caloric value of the sample was calculated using "Atwater factor" by multiplying the value of the crude protein, lipid and carbohydrate by 4, 9, 4 respectively and taking the sum of the product (Onwuka, 2005). Carbohydrate content was estimated by subtracting the values obtained for fat and protein from organic matter (Onwuka, 2005). All the experiments were recorded in triplicates and the proximate values are reported in g/100g (Anon, 2003; Hussain *et al*., 2010; Hussain *et al*., 2011).

Estimation of mineral element from fruit samples**:** Mineral elements estimations indicate the amount of inorganic elements present in the sample. The determination of Mineral Element from the *P. armeniaca* L. fruit samples was determined by using standard procedures. During the determination, the sample was first ashed and dissolved in a solvent, and the resultant solution aspirated into an air-acetylene flame. The mineral element determined were; Sodium (Na), Potassium (K), Calcium (Ca), Iron (Fe), Magnesium (Mg), Manganese (Mn) and Zinc (Zn) and this was done spectrophotometric methods, using flame emission spectrophotometer for Sodium (Na) and Potassium (K) and atomic absorption spectrophotometer (Perkin Elmer model 1100) for others (A.O.A.C., 1990).

Soil samples collection and analysis**:** Soil samples were collected from several random locations from each quadrat, a soil sample was taken at the depth of 10-15 cm of the topsoil with the help of stainless steel trowel. Fresh soil samples were dried and then passed through 2mm sieve. One gram of soil was taken in acid washed beaker with 10ml Aqua regia, ($1HNO_3$:3HCl). It was left for 24 hours for complete digestion. After 24 hours soil sample was refluxed at reflux condenser for about 30 minutes and cooled at room temperature. Then it was filtered by Whattman (42) filter paper and volume made up to 25 ml with de-ionized water. Soil samples were measured for pH, electric conductivity, and the major ions Na^+, K^+, Ca^{+2}, Mg^{+2}, Cl^-, HCO^-_3 and SO^{-2}_4. The pH measurements were performed with pH electrode (WTW pH 323) and the electric conductivity with conductivity meter in separate sample aliquots. The anions Cl^-, HCO^-_3 and SO^{-2}_4 were measured by ion chromatography. Ca^{+2}, Mg^{+2} were determined by flame atomic absorption spectrometry (Perkin Elmer model 1100). Na^+ and K^+ were measured by flame photometry.

Leaves samples analysis**:** Samples of leaves were collected from *P. armeniaca* L. trees and washed gently by distilled water which was collected in a clean, weighed beaker and then evaporated to determine the weight of washed dust as μg/cm^2 of the leaf area which was measured using a digital planimeter (Bolab model 40) with a sensitivity of 0.1 cm^2. The washed leaves were collected for determination of pigment contents according to Metzner *et al.* (1965) and leaf area was determined by using leaf area meter.

RESULTS AND DISCUSSION

Results illustrated in Table 1 indicated that the level of investigated mettles in soil varied significantly according to the distance of the four locations (1, 2, 3 and control) from the dust crushing units. Similar results reported by Abdel-Rahman, (2012). He found that there was significant variation in soil characteristics according to the distance of the cement factory.

Test Statistic showed that pH of soil solution in more polluted locations 1, 2 and 3 were highly to slightly significant (8.1, 8.0, 7.9) with respect to the control (7.6) and Electrical Conductivity (EC) also increased highly to slightly significant because of stone dust (40.6, 34.6, 4.6 ds/m) for locations 1, 2 and 3 respectively compared with the control (2.1ds/m). The level of Na, K, Ca, Mg, Cl and SO_4 was highly to slightly significant in the soil of polluted side1, 2 and 3 respectively, than in the control side soil, while there was no significant difference between the level of HCO in polluted and control

Table 1. Summary of pair sample t-test at 95% confidence level for the variation in soil physical and chemical characteristics of study area.

Parameters		Distance from Stone Crusher Plants			
		500m	1000m	1500m	Control
pH	Mean	8.1 ±0.1	8.0 ±0.1	7.9 ±0.1	7.6 ±0.1
	t. value	16.0	3.5	2.6	
	Sig (2 tailed)	0.004	0.076	0.122	
EC (ds/m)	Mean	40.6 ±1.4	34.6 ±1.4	4.6 ±0.5	2.1 ±0.1
	t. value	25.0	21.2	5.7	
	Sig (2 tailed)	0.002	0.002	0.029	
Na (meq/L)	Mean	170.5 ±11.6	156.0 ±8.6	30.3 ±1.7	11.1 ±1.4
	t. value	14.9	15.2	7.0	
	Sig (2 tailed)	0.004	0.004	0.020	
K (meq/L)	Mean	7.2 ±0.4	6.4 ±0.2	3.4 ±0.3	1.7 ±0.5
	t. value	31.8	19.4	7.9	
	Sig (2 tailed)	0.001	0.003	0.016	
Ca (meq/L)	Mean	142.0 ±6.5	99.8 ±5.7	16.3 ±1.5	6.3 ±1.3
	t. value	17.8	21.4	5.0	
	Sig (2 tailed)	0.003	0.002	0.028	
Mg (meq/L)	Mean	62.2 ±2.3	78.6 ±2.0	94.9 ±6.5	43.2 ±7.3
	t. value	9.7	6.6	20.5	
	Sig (2 tailed)	0.010	0.022	0.002	
Cl (meq/L)	Mean	338.3 ±23.2	273.0 ±12.7	44.5 ±2.6	14.2 ±2.3
	t. value	15.6	24.7	102.5	
	Sig (2 tailed)	0.004	0.002	0.000	
HCO_3 (meq/L)	Mean	7.4 ±0.4	7.13 ±0.5	8.2 ±0.4	6.03 ±0.4
	t. value	1.6	1.8	2.7	
	Sig (2 tailed)	0.246	0.224	0.113	
SO_4meq/L	Mean	31.2 ±3.3	33.9 ±2.3	5.43 ±1.5	1.57 ±0.4
	t. value	10.1	16.7	20.8	
	Sig (2 tailed)	0.010	0.004	0.002	

±: Stander error

soils (Table 1). Observation reported by Sivakumar and Britto (1995) and Bacic *et al.* (1999) are agreement with these results. They noticed that the level of $CaCO_3$ and oxide of potassium, silicon and Na_2SO_4 increased significantly due to atmospheric dust pollution produced by cement. They also found that the soil near the cement factory contains high concentration of heavy metals and halogens like thallium and iodine, this dust falling on the soil caused a shift in pH to the alkaline side and increase in soluble salts in it.

Results reported by Aukour and Al-Qinna (2008) are also comparable with these results. They found that dusts have been found migrating and running in roads and sidewalks, accumulation of more than 5cm above the soil surface knowing that Jordanian soils is already calcareous of pH around 8.2 restricting the availability of some nutrients for plant uptake. Dust may be arising from vehicle movements on unsealed roads and can also occur as a result of winds or storms or neighboring industries such as marble.

Statistical data listed in Table 2 exhibited that the number of branches/tree (79.5, 60.7, 26.1 & 11.6), number of fruits/branch (37.8, 26.7, 14.6 & 8.4) and leaf area (41.5, 33.6, 20.7 & 12.4 cm^2) exhibited a significant decrease in response to stone dust according to the distance of the four locations (control and location 3 to 1), respectively. This is in agreement with those results reported by Leghari and Zaidi (2013). They reported that all plant species exhibited significant ($p<0.05$) decline at polluted site in their leaf length, width, area and petiole length when compared with the same plant species of non-polluted site. The amount of deposited dust on leaf surfaces (4.30, 2.6, 1.17, 0.3 $\mu g/cm^2$) varied significantly according to the distance of the four locations (1, 2, 3 and control) from the crushing units, respectively. Fruit phytomass (Economic yield) on dry weight basis per tree (0.4, 2.3, 12.2 & 22.7 kg.d.wt/tree) and fresh wt basis per tree (2.6, 12.6, 62.7 & 98.3 kg d.wt/tree) also recorded a highly significant decrease in response to increase the stone dust at location 1 to 3 and control, respectively (Table 2). The reduction in growth may be due to toxic effect of different heavy metals which was found in stone dust. Similar results were also noted by Abdel-Rahman, (2012). He found that in response to increased cement dust the yield of *Ficus carica* L. fruits at more polluted locations decreased

Table 2. Summary of pair sample t-test at 95% confidence level for the variation in Plant characteristics and Fruit yield.

Parameters		Distance from Stone Crusher Plants			
		500m	1000m	1500m	Control
No. of Branches/tree	Mean	11.6 ±1.3	26.1 ±3.3	60.7 ±3.1	79.5 ±2.6
	t. value	52.2	64.7	29.7	
	Sig (2 tailed)	0.000	0.000	0.000	
No. of fruit/Branch	Mean	8.4 ±0.5	14.6 ±2.5	26.7 ±2.0	37.8 ±2.1
	t. value	18.6	57.1	83.0	
	Sig (2 tailed)	0.003	0.000	0.000	
Leaf area (cm2)	Mean	12.4 ±1.6	20.7 ±2.1	33.6 ±2.1	41.5 ±2.2
	t. value	8.8	5.9	2.2	
	Sig (2 tailed)	0.013	0.028	0.162	
Dust on leaf ($\mu g/cm^2$)	Mean	4.30 ±0.5	2.6 ±0.4	1.17 ±0.3	0.3 ±0.02
	t. value	7.4	6.8	2.9	
	Sig (2 tailed)	0.018	0.021	0.104	
Yield/tree on fresh wt basis	Mean	2.6 ±0.4	12.6 ±1.5	62.7 ±3.4	98.3 ±2.7
	t. value	32.0	73.7	5.9	
	Sig (2 tailed)	0.001	0.000	0.028	
Yield/tree on dry wt. basis	Mean	0.4 ±0.03	2.3 ±0.2	12.2 ±1.7	22.7 ±1.4
	t. value	15.8	17.6	29.6	
	Sig (2 tailed)	0.004	0.003	0.001	

Table 3. Summary of pair sample t-test at 95% confidence level for the variation in Plant leaves pigments.

Pigments		Distance from Stone Crusher Plants			
		500m	1000m	1500m	Control
Chlorophyll, a (mg/g.f.wt)	Mean	0.40 ±0.01	0.70 ±0.01	0.91 ±0.3	1.40 ±0.1
	t. value	9.7	6.5	4.1	
	Sig (2 tailed)	0.010	0.023	0.054	
Chlorophyll, b (mg/g.f.wt)	Mean	0.17 ±0.01	0.23 ±0.01	0.35 ±0.03	0.38 ±0.03
	t. value	5.1	3.3	2.3	
	Sig (2 tailed)	0.037	0.082	0.157	
Carotenoids (mg/g.f.wt)	Mean	0.10 ±0.00	0.14 ±0.01	0.25 ±0.01	0.27 ±0.01
	t. value	18.9	11.3	7.0	
	Sig (2 tailed)	0.003	0.008	0.020	

about (0.5%-6.0% respectively) and in less polluted location about 50% compared to the control. Leghari *et al.* (2014) revealed that there was negative correlation between the amount of dust accumulation and plant growth parameters as the amount of dust increased plant growth decreased, respectively. This is in agreement with other researchers observations (Ade-Ademilua and Obalola, 2008; Prasad and Inamdar, 1990; Iqbal and Shafiq, 2001).

Photosynthetic pigments (Chlorophyll a, Chlorophyll b, carotenoids) in *P. armeniaca* L. leaves were highly significantly declined with high stone dust accumulation (Table 3) at locations 1 and 2, whereas at location 3 it showed slightly decline with respect to control. This leads to a decrease in photosynthetic rate and quantum yield and might be causes quantitative as well as qualitative changes in the incident light available for photosynthesis in stone dusted leaves. These findings confirmed the previous results by Singh and Rao (1980) on wheat plants, Prasad and Inamdar (1991) on *Vigna mungo* and Nanos and Ilias (2007) on olive leave physiology. A significant reduction in plant length, cover, number of leaves, leaf area and total chlorophyll contents for *V. vinifera* L. due to dust application was also observed by Leghari *et al.* (2014).

Essential elements, such as Na, K, Ca Fe, Mg, Mn and Zn play an important role in plant fruit nutrition. When these essential elements not present in appropriate concentration levels they can affect crop yields and fruits quality (Pestana *et al.*, 2004). In the present investigation test statistic for electrolytes such as Na and K showed slightly to highly significant decline concentration in the fruits of *P. armeniaca* L. du to stone crusher dust from location 3 to 1 with respect to control (Table 4), respectively. Seufert (1990) reported that, higher concentrations of air pollutants may increase or decrease the

Table 4. Summary of pair sample t-test at 95% confidence level for the variation in Electrolytes and Minerals contents in *Prunus armeniaca* L. fruits.

Parameters (mg/100g)		Distance from Stone Crusher Plants			
Electrolytes		500m	1000m	1500m	Control
Sodium (Na)	Mean	0.2 ±0.01	0.9 ±0.03	1.2 ±0.2	1.7 ±0.2
	t. value	14.0	5.6	9.5	
	Sig (2 tailed)	0.001	0.003	0.005	
Potassium (K)	Mean	94.7 ± 2.5	152.0 ±13.2	205.0 ±14.4	243.5 ±7.1
	t. value	32.1	12.1	5.2	
	Sig (2 tailed)	0.001	0.007	0.035	
Minerals Calcium (Ca)	Mean	20.5 ±1.4	17.5 ±1.1	13.7 ±1.6	11.7 ±1.5
	t. value	49.5	14.6	6.5	
	Sig (2 tailed)	0.000	0.005	0.023	
Iron (Fe)	Mean	0.84 ±0.01	0.80 ±0.01	0.76 ±0.02	0.64 ±0.02
	t. value	118.0	77.0	17.3	
	Sig (2 tailed)	0.000	0.000	0.003	
Magnesium (Mg)	Mean	12.6 ±1.3	10.3 ±1.3	10.0 ±1.5	8.1 ±1.2
	t. value	22.0	2.8	2.4	
	Sig (2 tailed)	0.020	0.119	0.143	
Manganese (Mn)	Mean	2.13 ±0.2	1.8 ±0.2	1.4 ±0.2	0.24 ±0.02
	t. value	7.7	7.5	5.6	
	Sig (2 tailed)	0.017	0.017	0.031	
Zinc (Zn)	Mean	0.6 ±0.1	0.4 ±0.02	0.3± 0.02	0.23 ±0.2
	t. value	18.9	22.5	2.3	
	Sig (2 tailed)	0.003	0.002	0.117	

Table 5. Summary of pair sample t-test at 95% confidence level for the variation in proximate contents in *Prunus armeniaca* L. fruits.

Proximate Contents		Distance from Stone Crusher Plants			
		500m	1000m	1500m	Control
Energy (Kcal/100g)	Mean	30.0 ±1.4	36.2 ±1.1	46.2 ±1.2	56.0 ±2.1
	t. value	7.5	5.0	9.0	
	Sig (2 tailed)	0.018	0.035	0.012	
Carbohydrate (g/100g)	Mean	5.0 ±0.4	8.3 ±0.5	12.8 ±0.9	16.0 ±0.8
	t. value	9.7	6.2	3.0	
	Sig (2 tailed)	0.011	0.025	0.104	
Protein (g/100g)	Mean	0.40 ±0.1	0.73 ±0.1	1.30 ±0.1	1.93 ±0.1
	t. value	11.5	7.0	7.1	
	Sig (2 tailed)	0.007	0.020	0.019	
Total Fat (g/100g)	Mean	0.02 ±0.0	0.09 ±0.0	0.66 ±0.1	0.82 ±0.7
	t. value	12.0	9.0	2.3	
	Sig (2 tailed)	0.007	0.012	0.150	
Dietary Fibers (g/100g)	Mean	4.66 ±0.7	4.10 ±0.3	2.27 ±0.2	2.77 ±0.1
	t. value	7.2	22.5	3.3	
	Sig (2 tailed)	0.002	0.019	0.082	

uptake of nutrients by the roots. In addition to polluted soil effects on the availability of nutrients (Oren, 1996).

The present study showed that, stone dust had a significant effect on Minerals elements such as Ca Fe, Mg, Mn and Zn in edible mature fruits (Table 4). The average concentration of Ca, Fe, Mg, Mn and Zn were more accumulated in the fruits in response to more stone dust near the crushing units at location 1to 3. Similar results were noticed by Ade-Ademilua (2008), who reported that, there was positive correlation between pollution and concentration of Fe and Mg in leaves and stems of *Celosia argentea*, as the cement dust pollution increased the concentration of Fe and Mg in leaves and stems of *C. argentea* also increased.

The average concentration of proximate constituents varied significantly with the distance from the stone crushing units. Test Statistics showed that average Energy (46.2, 36.2, and 30.0 Kcal/100g), Carbohydrate (12.8, 8.3, and 5.0 g/100g) and Protein (1.30, 0.73, and 0.40 g/100g) contents in the mature fruits of *P. armeniaca* L. exhibited a slightly high significant decrease trend in response to increase in stone dust from location 3 to 1, respectively (Table 5). These results agree with those of many investigations on different plant species who reported that, the metabolites decreased in dusted plants as compared to control (Singh and Rao, 1980; Prasad and Inamdar, 1991). The finding of Abdel-Rahman (2012) were also agreement with these results, as he found that the mature fruits of *Ficus carica* L. had maximum reduction in the concentrations of total available carbohydrates, protein and total soluble sugars at the most polluted site near the cement factory.

The total fat content listed in Table 5 obtained for the fruit of *P. armeniaca* L. was 0.02, 0.09, 0.66 & 0.82 g/100g at location 1to 3 and control, respectively. These results exhibited highly significantly declined with high stone dust accumulation (Table 5) at locations 1 and 2, whereas at location 3 it showed slightly decline with respect to control. This low level of Total fat at location 1 is considered because of high contents of fibers at same location. The Fibers in food or plant leaves is an indication of the level of non-digestible carbohydrate and lignin. The Fibers obtained for *P. armeniaca* L. fruit was 4.66, 4.10, 2.27 & 2.77 g/100g at four locations from 1 to 3 and control, respectively. It showed slightly to highly significant increasing trend in response to increase in stone dust from location 3 to location 1, respectively. Its presence in high level can cause intestinal irritation, lower digestibility and decreased nutrient usage (Oladiji and Mih, 2005). Fibers are made up largely of cellulose together with a little lignin which is indigestible in human (Onwuka, 2005).

***Conclusion*:** On the basis of this study, it could be concluded that, yield and quality of *P. armeniaca* L. fruits were found to be significantly affected by the influenced of stones crusher dust at high rates which might be due to the presence of different toxic pollutants in dust especially heavy metals which are significance for plants, animals and human health. Stones crusher dust seems to cause substantial changes to leaf physiology by destroying the photosynthetic pigments and interrupted the proximate of energy, carbohydrates, proteins and fats. It also affected on soil characteristics and the uptake and accumulation of essential nutrient elements from the soil which finally affected on the economic yield of trees, quantitatively and qualitatively.

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