Using Rain Water in Jeddah in Kingdom of Saudi Arabia as an indicator to air pollution and its impact on seed germination of *Phaseolous vulgaris* and Lentil (*Lens culinaris*)

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Abstract: In this study, the impact of rainwater harvested from different sites in Jeddah, KSA, , *Viz*, Al-Tahlia, Al-Rawda and Al-Basateen*,* was investigated chemically, physically and regarding different growth parameters of *Phaseolus vulgaris* and *Lens culinaris* seeds (under laboratory conditions) and heavy metals content. The average solubility of the trace metals in the rain waters increase in the order: Mn, Ni, Zn, Cu, Ba, Cr, As, Pb and Cd. Rainwater was slightly acidic in all sites except at Al-Basateen which was slightly alkaline and with high Ec compared to control and other rain waters (P>0.01). *Phaseolus vulgaris* showed noticeable increase in cotyledons, fresh ; dry weights, and stem length in all sites.. On the other hand, *Lens culinaris* recorded high values of cotyledons and stem fresh and dry weights, as well as, reasonable root and stem length. Moreover, results have shown that the significant parameters in terms of acute air pollution are not identified. Thus, irrigation with harvested rainwater can be considered as one of the most valuable easy technologies that can assist in saving irrigation water and substituting water scarcity.

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Keywords: *Rain water harvesting, air pollution,. Phaseolous vulgaris, Lens culinaris, heavy metals, trace elements*.

1. Introduction

Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots, as well as, more complex techniques such as underground check dams ,Qiang and Yuanhong (2004); Rachwal and Holt (2008). Techniques used usually in Asia and Africa arised from practices employed by ancient civilizations within these regions and still served as a major source of drinking water supply in rural areas ,Pachpute, *et al*., (2009); Pachpute (2010). Systems used in rain water harvesting are constructed of three principal components; namely, the catchment area, the collection device, and the conveyance system, Gould (1992) and Pachpute, *et al*., (2009).

Rain is the ultimate source of fresh water, Haebler and Waller (1987); Macomber (2001); Morgan andTravathan (2002); William(2009).

With the ground area around houses and buildings being cemented, particularly in cities and towns, rainwater, which runs off from terraces and roofs, is draining into low-lying areas and not percolating into the soil. Thereby, precious rainwater is squandered, as it is drained into the sea eventually.

Rainwater harvesting can be a good indicator to air pollution in cities like Jeddah. Two significant sources of air pollution are impacting on the health of people and environment of the city ,Abulfaraj, *et al*., (2009); Vasudevan(2002); Thamer *et al*., (2007) ;Che-Ane(2009). The stationary sources are of high priority for action to cause air pollution in Jeddah. The sources include the Jeddah oil refinery, the desalinization plant (picture 4), the power generation plant and several industries on the Jeddah industrial area. Other less evident and small scale activities influence neighborhoods in Jeddah. The second source is mobile including all forms of transportation. This is of lower priority for action within the context of this study but not in terms of national action.

In view of the fact that, agriculture is a major user of water resources in many regions of the world and with increasing acidity and a growing population, water will become an even scarcer commodity in the near future ,Rahman(2009). This study aimed to find alternative water source from rain to irrigate the main crops in Jeddah. Chickpea (*Cicer arietinum* L.) with 17-24% protein (Nahid, 2011) is one of the most important legume plants in providing human food. *Phaseolous vulgaris* on the other hand, is high in starch, protein and dietary fiber and is an excellent source of iron, potassium, selenium, molybdenum, thiamine, vitamin B6, and folic acid ,Susan et al., (1989).

2. Materials and Methods:

2.1. Experimental work

2.1.1. Rain Water Harvesting

The roof of buildings or houses is the obvious first choice of rain catchment. Water tanks were used just under water pipes of houses in different places in Jeddah city namely, Al-Rawda, Al-Basateen and Al- Tahlia sites (pictures, 1, 2 and 3) respectively. Water quality from different roofs catchment is considered a function of the climatic conditions and the surrounding environment. Roofs with clay and concrete were used while those copper and zinc flashing were avoided (as was suggested by Heijerick *et al*., (2002) ; Ibraimo and mungumbe(2007).

2.1.2. Chemical analysis of rain water

Some elements content of rain water *viz*, Copper (Cu), Lead (Pb), Zink (Zn), Nickle (Ni), Manganese (Mn), Cadmium (Cd), Chromium (Cr), Barium (Ba) and Arsenine (As) were analyzed by atomic absorption. In addition, Ec and pH were measured.

2.2 . Seeds germination

Seeds of *Phaseolous vulgaris* and lentil (*Lens culinaris*) were germinated in Petri-dishes under normal lab condition. Seeds were immersed in different rain waters and continued to be irrigated with the particular rain water from the different places type till the emergence of roots and cotyledons. Seedlings were then collected for further analysis.

2.3. Seedlings parameters

Fresh and dry weights of roots, stems, leaves and cotyledons were recorded using a sensitive balance. Seedlings were chemically analyzed in terms of some elements contents.

2.4. Statistical analysis

Statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS) for Windows version 18.0. All data were represented as mean ± standard error (SE). Data were subjected to one way analysis of variance (ANOVA).

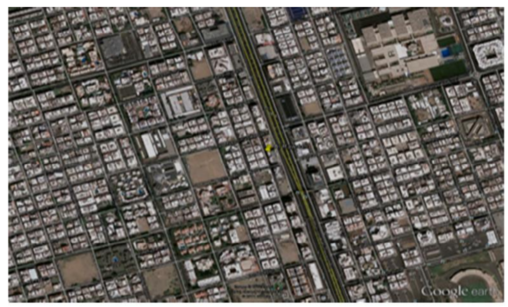
3. Results and Discussion

3.1. Chemical characteristics of rain water:

The data of the analysis were presented in Tables 1 & 2. Accumulation trend of all the studied heavy metals in rain water, were to some extend differ from site to other. In general, Manganese (Mn), Nickle (Ni), copper (Cu), Zinc (Zn) Arsenate (AS) and Barium (Ba) recorded their maximum values at Al-Basateen site.The recorded values were: 1.78 ppm, 3.27 ppm, 0.47 ppm, 1.16 ppm and 0.38 ppm, respectively (Table 1). In contrast, the rain water harvested from Al-Tahlia site recorded low values of theses metals (0.58 ppm, 0.15 ppm, 0.20 ppm, 0.80 ppm and 0.10 ppm for Mn, Ni, Cu, Zn, As and Ba respectively. On the other hand, Al-Rawda site represented values between the other two sites except in Barium (Ba) and lead (pb) where it recorded the respectively high values among other sites (0.82 and 0.13 ppm, respectively).

Table 2: Conductivity (us/cm) and pH of rainwater collected from different site in Jeddah

Site	Cond. Us/cm	pH
Control (Distilled water)	2.19±0.38^{a}	6.15±0.37^{a}
Al-Tahlia	20.07±0.18^{b}	6.38±0.02^{a}
Al-Rawdah	11.48±0.09^{c}	6.13±0.09^{a}
Al-Basateen	52.90±0.97^{d}	7.72±0.01^{b}



Picture (1) Al-Rawda Site. Source: Google Earth 2012

Picture (2) Al-Basateen site (near King Abdulaziz airport). Source: Google Earth 2012

Table 1: ***Chemical analysis of rainwater harvested from different site in Jeddah (mg/l)***

Site	Mn	Ni	Cu	Zn	As	Cd	Ba	Pb	Cr
Control (Dist.water)	<0.10^{a}	0.16 ±0.0	<0.10	0.19 ±0.16	<0.10	<0.10	<0.10	<0.10	<0.10
Al-Tahlia	0.58 ±0.0^{b}	.15 ±0.0	0.20 ±0.01^{b}	0.80 ±0.02^{b}	0.10 ±0.0	0.10 ±0.0	0.24 ±0.01^{a}	<0.10	0.32 ±0.01
Al-Rawdah	1.73 ±0.06^{c}	.16 ±0.02	0.13 ±0.01	1.06 ±0.04^{c}	0.10 ±0.0	0.10 ±0.0	0.82 ±0.01^{c}	0.13 ±0.02	<0.10
Al-Basateen	1.78 ±0.07^{d}	3.27 ±0.14^{a}	0.47 ±0.02^{c}	1.16 ±0.01^{c}	0.38 ±0.01^{a}	0.10 ±0.0	0.58 ±0.01^{b}	<0.10	<0.10

The data are expressed in mean ± SE. n=3 in each group.

Means marked with different letters in the same column significantly differ at 5% level of probability

Picture (3) Al-Tahlia Site. Source: Google Earth 2012

Picture (4): The desalinization plant in Jeddah

The presence of relatively high level of heavy metal and alkaline pH observed in Al-Basateen site can be attributed to the fact that this site is located just a few miles from King Abdulaziz airport (picture 2).

Results in Table (2) revealed that Al-Basateen site has the highest EC (52.9 us/cm compared to 2.19 ppm of the control) where as the lowest EC was reported in Al-Rawda site (20.07 us/cm). Al-Basateen recorded slightly basic rain water (pH 7.72) compared to other sites which recorded slightly acidic rain waters. The acidity of other sites can be suggested to be due to the following fact:

As a rain drops falls and comes in contact with the atmosphere, it dissolves naturally occurring carbon dioxide to form a weak acid; this caused the resultant pH to be acidic.

Worth mentioning is that, rain water harvested from all sites recorded very low levels of Arsenate (As), Cadmium (Cd), Lead (pb) and Chromium (Cr.)

3.2. Chemical characteristics of *Phaseolous vulgaris* and *Lens culinaris* watered with different rain waters:

Data in Table (3) indicates that *Phaseolous vulgaris* plants watered with rain water harvested from Al-Basateen accumulated more heavy metals in their tissues compared to their correspondence that watered from other sites' rains. Moreover, there is no significant difference between rain water of Al-Tahlia and Al- Rawda compared to the control.

On the other hand, *Lens culinaris* (Table 4), has accumulated high levels of heavy metals when watered with rain water harvested from Al-Rawda site in terms of Mn, Ni, Cu and Zn (35.5 ppm, 42.5 ppm, 37.5 ppm and 47.0 ppm) respectively. In industrial areas, rain water samples can have slightly higher values of suspended solids concentration and turbidity due to the greater amount of particulate matter in the air, Thomas and Grenne (1993); Ayodele, and Abubakar (1998).

Table 3: Chemical analysis of Phaseolous vulgaris seedlings grown with rainwater collected from different site in Jeddah (mg/l)

Site	Mn	Ni	Cu	Zn	As	Cd	Ba	Pb	Cr
Control (Distilled water)	30.50 ±2.5	50.00 ±0.0	16.50 ±0.5	36.50 ±5.5	<100.0 ±0.0	<2.00 ±0.0	<10.00 ±0.0	<5.0 ±0.0	<4.00 ±0.0
Al-Tahlia	33.50 ±1.5	47.50 ±2.5	13.50 ±0.5^{b}	35.50 ±7.5	<100.0 ±0.0	<2.00 ±0.0	<10.00 ±0.0	<5.0 ±0.0	<2.00 ±0.0
Al-Rawdah	31.00 ±1.0	50.00 ±0.0	15.50 ±0.5	36.50 ±1.5	<100.0 ±0.0	<2.00 ±0.0	<10.00 ±0.0	7.5 ±2.5^{b}	<4.00 ±0.1
Al-Basateen	36.50 ±0.5^{b}	50.00 ±0.0	16.50 ±0.3	38.00 ±0.0	<100.0 ±0.0	<2.00 ±0.0	<10.00 ±0.0	<5.0 ±0.0	<2.00 ±0.1

The data are expressed in mean ± SE. n=3 in each group.

Means marked with different letters in the same column significantly differ at 5% level of probability

Table 4: Chemical analysis of lentil (Lens culinaris) seedlings grown with rainwater collected from different site in Je

Site	Mn	Ni	Cu	Zn	As	Cd	Ba	Pb	Cr
Control (Distilled water)	40.0 ±0.0	65.0 ±0.0	27.0 ±0.0	23.0 ±0.0	<100.0 ±0.0	<2.0 ±0.0	<10.0 ±0.0	<5.0 ±0.0	<2.0 ±0.0
Al-Tahlia	24.5 ±0.7^{c}	42.5 ±3.5^{a}	16.0 ±2.8^{b}	34.5 ±0.5^{a}	<100.0 ±0.0	<2.0 ±0.0	<10.0 ±0.0	<5.0 ±0.0	<2.0 ±0.0
Al- Rawdah	^{b}35.5 ±3.5	42.5 ±3.5^{a}	37.5 ±0.7^{a}	47.0 ±1.0^{b}	<100.0 ±0.0	<2.0 ±0.0	<10.0 ±0.0	<5.0 ±0.0	<2.5 ±0.5
Al -Basateen	28.0 ±0.0^{c}	40.0 ±0.0^{a}	20.0 ±0.0^{a}	29.0 ±0.0^{a}	<100.0 ±0.0	<2.0 ±0.0	<10.0 ±0.0	<5.0 ±0.0	<2.0 ±0.0

The data are expressed in mean ± SE. n=3 in each group.

Means marked with different letters in the same column significantly differ at 5% level of probability

3.3 Plants Growth Parameters:

Figures (1-6) illustrated plants growth parameters in terms of cotyledons, root, and stem (fresh and dry) weights, in addition to shoot and root length and width of the two plants. The highest shoot fresh weight of *Lens culinaris* was recorded in the plants watered with distilled water (control, 0.25 g) followed by rain water of Al-Rawda (0.23 mg). The lowest value of fresh shoot weight was in Al-Tahlia site, which recorded the lowest fresh root weight also. Nonetheless, lentil plants watered with Al-Tahlia rains achieved the highest cotyledons weight (Figure 1).

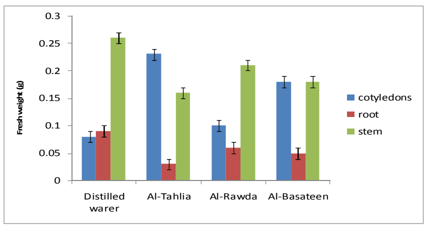


Figure 1: Cotyledons, root and stem fresh weight (g) of lentil (Lens culinaris) seedlings grown with distilled water and rainwater collected from different site in Jeddah.

Figure 2 demonstrated the impact of rain water harvested from different sites on dry weights of Lentil plants. The highest shoot dry weight was recorded in Al-Rawda site (0.08 g) whereas the lowest weight of shoot was recorded in Al-Tahlia site (0.02 g) with a reduction of 75%. Contrary, plants watered with Al-Tahlia rain achieved the highest cotyledons weight (0.04 g) compared to control (0.01 g) followed by Al-Basateen and finally Al-Rawda.

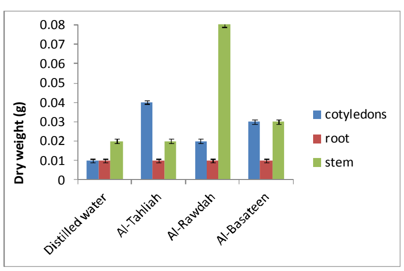


Figure 2: Cotyledons, root and stem dry weight (g) of lentil (Lens culinaris) seedlings grown with distilled water and rainwater collected from different site in Jeddah.

Figure 3 indicated that, *Phaseolous* plants fresh weights showed different response to rain water harvested from different sites in Jeddah. The highest values of cotyledon fresh weight was recorded at Al-Basateen (0.9 g) followed by Al-Tahlia, , control and finally Al-Rawda site. Root fresh weights showed no significant difference among different rainwater but they showed a significant decrease from the control. Stem fresh weights of *Phaseolous* plants followed the pattern: control> Al-Basateen> Al-Rawda> Al-Tahlia.

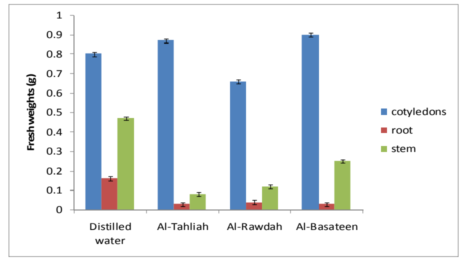


Figure 3: cotyledons, root and stem fresh weight (g) Phaseolous vulgaris seedlings grown with distilled water and rainwater collected from different site in Jeddah.

With regard to dry weights (Figure 4), Phaseolous plants watered with rain water collected from Al-Tahlia site achieved the highest cotyledons dry weight, followed by Al-Basateen, Alrawda and finally the control plants. On the other hand, there is no significant difference between treatments regarding shoot and root dry weights.

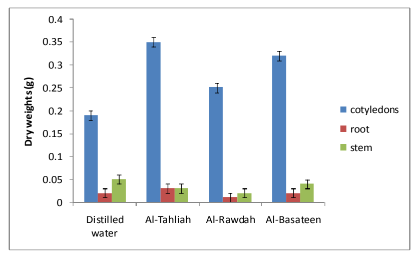


Figure 4: Cotyledons, root and stem dry weight (g) Phaseolous vulgaris seedlings grown with distilled water and rainwater collected from different site in Jeddah.

Figure 5 demonstrated stem and root length and width of *Phaseolous* plants. The highest value of stem length was recorded in the controlled plants (12.7 cm), followed by Al-Rawda site (11.2 cm), Al-Basateen (8.2 cm) and then Al-Tahlia (6.7 cm). Root length also followed this pattern. The highest root length was achieved by *Phaseolus* plants watered with distilled water (7.4 cm), followed by plants watered with rain water harvested from Al-Rawda, (5.3 cm), Al-Basateen (3.0 cm), and finally Al-Tahlia (1.5 cm). On the other hand, there is no significant difference between treatments concerning stem and root widths.

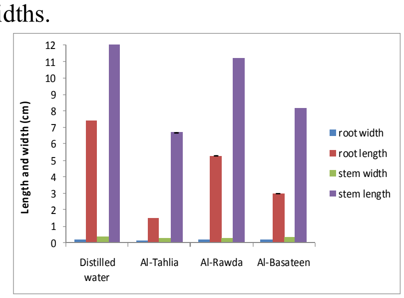


Figure 5: Root and stem length and width (cm) of Phaseolous vulgaris seedlings grown with distilled water and rainwater collected from different site in Jeddah.

Figure 6 illustrated root and stem lengths and width of lentil plants. Control plants recorded the highest value of stem length (6.5 cm) followed by Al-Basateen (4.0 cm), Al-Rawda, (2.9 cm) and finally Al-Tahlia (2.4cm). On the other hand, root lengths of lentils plants showed the highest value in plants watered with rain water collected from Al-Rawda site (5.5 cm), followed by control (5.0 cm), Al-Basateen (3.0 cm), and then Al-Tahlia (2.0 cm). Nonetheless, shoot and root widths values showed no significant difference between all treatments including the control.

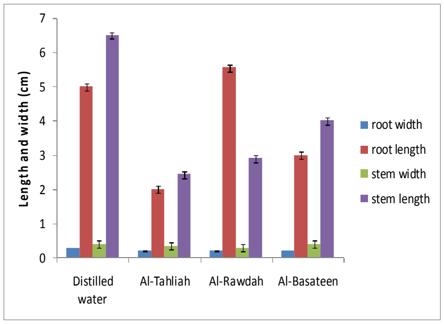


Figure 6: Root and stem length and width (cm) of lentil (Lens culinaris) seedlings grown with distilled water and rainwater collected from different site in Jeddah.

Rain water assisted the two plants to have biomass almost similar to control with reasonable amount of accumulated metal in their tissues. This type of water is suitable for seed germination which was also reported by Bewley (1994).

In conclusion, rain water collected from different sites in Jeddah did not show significant pollution and it was not an indicator to air pollution in Jeddah, although air pollution in Jeddah city was reported by other authors using other methods, Abulfarag *et al*., (2009). Rainwater harvested from the most polluted sites in Jeddah City recorded relatively reasonable amount of heavy metals. People should get benefit from the amount of rain water to be used in different ascpects of agriculture in terms of droplet irrigation or sprinkler system irrigation in green houses.

Hence, rainwater harvesting in Jeddah can provide a water source when groundwater is unavailable or unacceptable. In addition, irrigation with harvested rainwater can be considered as one of the most valuable easy technologies that can assist in saving irrigation water and substituting water scarcity.

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