Assessment of Different Water supplies in Jeddah as an indicator to water quality and their impact on seed germination

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Abstract: In this study, five water supplies in Jeddah city –Kingdom of Saudi Arabia (KSA), *viz,* Mineral water, Bottled water, Tap water, Zamzam water and Distilled water (as control) were investigated on germination and early seedling vigor of *Phaseolous vulgaris* and lentil (*Lens culinaris*) plants. Physico-chemical parameters in terms of heavy metals, EC and pH, were analyzed in water and plants in addition to some growth parameters of the plants. Results elucidated that, bottled water, which represents the main drinking water in Jeddah, showed similar results of elements to control (distilled water), followed by mineral water, Zamzam water and tap water. All water types were acidic except tap water and Zamzam water which were alkaline and they showed high electric conductivity(Ec) compared to control (P>0.01). The results showed that lentil plants watered with Zamzam water showed a pronounced increase in root fresh weight**,** while the high shoot weight was achieved with mineral water. On the other hand, plants watered with bottled water have high seeds dry weights in both plants. *Phaseolous vulgaris* plants watered with bottled water showed good growth parameters compared to the correspondence water types. Both plants accumulated the heavy element Ni in the same pattern (mineral water > bottled water > Zamzam water > tap water). However, from the present study, all water types in Jeddah seem to be safe for growing crop plants.

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Keywords: water supplies, water quality, heavy elements, Mineral water, Tap water, Bottled water, Zamzam water, Distilled water, seed germination.

1.Introduction

The evaluation of non-conventional water types quality and its impact on seed germination and seedling growth, in Jeddah, is still in progress. The water balance in the Jeddah area that is the supply, use and removal of water has changed rapidly with the growth of this city. In the early history of Jeddah water was a very scarce and expensive commodity (Al-Alawi and Abdulrazzak, 1994; Turki, 2009). The natural environment through rain and ground water could not supply the needs. Over the last years significant infrastructure has been established to provide residents throughout city with dependable water supply. Today, however, increased volumes and mixed contents of the water used in Jeddah that must be disposed of, is greater than the environment's natural ability to remediate it (Haddadin, 2002).

The supply of fresh water to the area comes from the desalinization of sea water from both the large plant and many smaller facilities and from the natural supplies of rain in the watershed east of Jeddah (Hussain and Al-Saati, 1999).

Past and present disposal of natural and used water from domestic and industrial users has created unacceptable conditions in downtown Jeddah and along the marine areas (Hussain and Al-Saati, 1999). It is now expensive to fix these conditions. With continued urban expansions, future disposal plans need to be made organizing the earlier problems encountered. There must be anticipation of new environmental and socio-economic consequences of developmental decisions .

2. Materials and Methods:

2.1. Experimental work

2.1.1. Collection of Water Types

Water samples, from different regions of Jeddah, *viz,* Mineral water, Bottled water, Tap water, Zamzam water (used by other people visiting KSA for Hajj or Omra) and Distilled water (as control), were collected and reserved in pre-cleaned polyethylene bottles, for chemical analysis.

2.1.2. Seeds germination

Sterilized seeds of *Phaseolous vulgaris* and lentil (*Lens culinaris*) were raised in continuous light in Petri-dishes at 25±2°C. Seeds were immersed in the above mentioned waters (3 replicates for each) and continued to be irrigated with the particular water type till the emergence of roots and shoots. Seedlings were then collected for further analyses.

2.2. Water Chemical Analysis

Water samples were analyzed for the evaluation of the dissolved-metal concentration: Manganese (Mg), Nickel (Ni), Copper (Cu), Zinc (Zn), Arsenic (As), Cadmium (Cd), Barium (Ba), Lead (Pb) and

Chromium (Cr). Metal determination were carried out by Atomic Absorption Spectrometer, model Mettler DL55/ DR 2010/ WTW.

2.3. Mineral Elements in Plants

Elements were determined after digestion of a definite weight of dry ground leaves according to Stewart (1983). Atomic Absorption Spectrometer, model Mettler DL55/ DR 2010/ WTW was used in elements determination.

2.4. Measurement of plant parameters

Some plants parameters were recorded 10 days after germinations. These included fresh and dry weights of root, stems, leaves and cotyledons (seeds), in addition to root and stem lengths and widths.

2.5. Statistical analysis:

Statistical analysis was performed employing one way ANOVA test using SPSS 18.0 software to detect the significant differences between treatments. All values (in Tables) are expressed as mean ± SDs.


Tap water


Mineral water


Distilled water


Bottled water


Zamzam water

Different water types used in the present study

3. Results and Discussion

3.1 Water types:

The results represented in Table 1, verified that the chemical analysis of Zamzam water contains a considerable amount of elements than that found in other water type in terms of Ni, As, Ba, and Cr. (3.1,ppb, 1.58 ppb, 11.o2 ppb and 0.53 ppb) of these elements respectively. On the other hand, the high values of Cu and Zn was recorded in tap water (1.52 ppb and 8.58 ppb) respectively.

Table 1: Chemical analysis (ppb) of water types in Jeddah

Water type	Mn^{+2}	Ni^{+2}	Cu^{+2}	Zn^{+2}	As^{+2}	Cd^{+2}	Ba^{+2}	Pb+2	Cr^{+6}
Control (Distilled water)	<0.10	0.16±0.0	<0.10	0.19± 0.16	<0.10	<0.10	<0.10	<0.1 0	<0.10
Mineral water	< 0.10	0.20±0.07^{a}	< 0.10	1.55±0.07^{a}	0.10±0.0	< 0.10	0.27	< 0.10	0.10
Bottled water	< 0.10	< 0.10	< 0.10	0.18±0.0	< 0.10	< 0.10	< 0.10	< 0.10	0.10
Tap water	0.15±0.07^{a}	1.29±0.14^{a}	1.52±0.02^{c}	8.58±0.01^{c}	0.12±0.01^{a}	<0.10±0. 0	1.13±0.01^{b}	<0.1 0	0.36
Zamzam water	< 0.10	3.100.01^{a}	0.130.01^{a}	0.10±0.0	1.58±0.07^{a}	< 10	11.02±0.07^{a}	< 10	0.53±0.07^{a}

The data are expressed in mean ± SD. *n*=3 in each group.
^{a} P< 0.05, ^{b} P < 0.01 & ^{c} P < 0.001, compared to control (Distilled water).

Table 2 clarified that, pH of Zamzam water was alkaline (8.11), while other water types were slightly acidic, except for tap water which was slightly alkaline (7.72). On the other hand, Zamzam water contained heavy elements more even than tape water, such as Ni, (3.10 PPT), As (1.58 PPT) and Ba (11.02 PPT). Nonetheless, all elements amounts were relatively low and within the safety range (Mutwally and Al-Sayaad 2002; Hamed *et a*l., 2009). Moreover, mineral water recorded low amounts of elements except for Zn, where it recorded 1.55 ppb (Table 1). Distilled water and Bottled water contain the least amount of elements and they recorded almost the same amount of all elements.

Table (2) indicated that, significant differences between treatments and control regarding Ec. Zamzam water and Tap water have the highest Ec and pH values (976.0 us/cm and 8.11) respectively which indicated basic values. Mineral water came next, it recorded 239.0 us/cm Ec followed by bottled water (161.0 us/cm) and then distilled water (2.19 us/cm). Worth mentioning is that, mineral water is almost neutral (pH= 6.99), as distilled water and bottled water; were slightly acidic.

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

Water Type	Cond. Us/cm	pH
Control (Distilled water)	2.19±0.38	6.15±0.37
Mineral water	239.0±0.18^{c}	6.99±0.02
Bottled water	161.0±0.09^{c}	6.13±0.09
Tap water	555.0±0.97^{c}	7.72±0.01^{b}
Zamzam water	976.0±0.18^{c}	8.11±0.01^{b}

The data are expressed in mean ± SD. *n*=3 in each group.
^{b} P < 0.01 & ^{c} P < 0.001 compared to control (Distilled water).
The data are expressed in mean ± SD. *n*=3 in each group.^{a} P< 0.05, ^{b} P < 0.01 & ^{c} P < 0.001, compared to control (Distilled water).

3.2Chemical analysis of *lens culinaris* and *Phaseolus vulgaris*

Chemical analysis of *Lens culinaris and Phaseolous vulgaris* which is represented in Table 3 & 4 respectively, clarified that, there was no significant difference in Mn content between Lens plants watered with different water types (Table 3). Nonetheless, higher accumulation of Ni, Cu, Zn and As was recorded in plants watered with tap water and Zamzam water.

3.3 Plants Growth Parameters:

The results of the present investigation verified the effect of different water supplies on growth parameters of lentils seedlings irrigated with different water types. Irrigation of lentil seeds with Zamzam water resulted in high root growth in term of fresh weight, followed by plants irrigated with tap water. These two waters reported the highest amount of Cu^{+2}, Zn^{+2} and Ni^{+2}, As^{+2} Cr^{+6} and Ba^{+2}respectively. Claire et al., (1991) obtained similar results in a study using nickel and other heavy metals on cabbage, lettuce, millet, radish, turnip, and wheat. Moreover, the highest stem fresh weight was recorded in lentils irrigated with mineral water (Fig. 1).

Conversely, high dry weight of cotyledon was reported in lentil plants were watered with bottled water (0.06 g compared to 0.04 g of the control, Fig. 2).

Roots and stems length and width, which were represented in Fig. 3, clarified that, lentils plants irrigated with tap water achieved the highest stem and root length compared to other treatments including the control (P≤0.001). Stem length recorded 7.5 cm compared to 1.6 cm of the control, while the root length reported 3.2 cm compared to 1.2 cm of the control. Lentils irrigated with Zamzam water, came next and The data are expressed in mean ± SD. *n*=3 in each group. It is recorded relatively high stem and root lengths compared to control (Fig. 3).

Table 3: Chemical analysis (mg/l) of lentil (*Lens culinaris*) seedlings grown with different water types in Jeddah

Water Type	Mn^{+2}	Ni^{+2}	Cu^{+2}	Zn^{+2}	As^{+2}	Cd^{+2}	Ba^{+2}	Pb^{+2}	Cr^{+6}
Control (Distilled water)	26.5±0.0	52.5.0±0.0	13.0±0.0	26.5±0.0	<100.0±0.0	<2.0±0.0	<10.0±0.0	<5.0±0.0	<2.0±0.0
Mineral water	37.0±0.7^{c}	60.0±3.5^{a}	16.0±2.8^{b}	52.0±0.5^{a}	<100.0±0.0	<2.0±0.0	<10.0±0.0	<5.0±0.0	<2.0±0.0
Bottled water	31.0±3.5	55.0±3.5^{a}	37.5±0.7^{a}	44.5±1.0^{b}	<100.0±0.0	<2.0±0.0	<10.0±0.0	<5.0±0.0	<2.0±0.5
Tap water	34.0±0.0^{c}	45.0±0.0^{a}	18.0±0.0^{a}	50.0±0.0^{a}	<100.0±0.0	<2.0±0.0	<10.0±0.0	<5.0±0.0	<2.0±0.0
Zamzam water	32±0.7^{c}	47±3.5	17±0.7^{c}	38±3.5	<100.0±0.0	<2.0±0.0	<12.5	10±0.7^{c}	<2.0±0.0

Table 4: Chemical analysis (mg/l) of *Phaseolous vulgaris* seedlings grown with different water types in Jeddah

Water Type	Mn^{+2}	Ni^{+2}	Cu^{+2}	Zn^{+2}	As^{+2}	Cd^{+2}	Ba^{+2}	Pb^{+2}	Cr^{+6}
Control (Distilled water)	35.5±2.5	62.5±7.5	19.0±0.5	45.5±5.5	<100.0	<2.00	<10.0.	<5.0±0.0	<2.00.
Mineral water	40.0±1.5	72.5±2.5	$18.50±0.5^{b}$	46.5±7.5	<100.0	2.00	<10.00	<5.0±0.0	15.5±0.
Bottled water	41.5±1.0	70.0±0.	15.50±0.5	48.5±1.5	<100.0	<2.00	<10.00	<5.0	3.5±01
Tap water	$37.50±0.5^{b}$	67.5±0.0	15.0±0.3	43.5±0.0	<100.0	<2.00	<10.00	<5.00	<2.00.
Zamzam water	$37±0.5^{b}$	$70±0.5^{b}$	16.5±0.3	$36±0.5^{b}$	<100.0	<2.00	<10.0±0	<5.0±0.0	<2.00.

[a] P< 0.05 & [b] P < 0.01, compared to control (Distilled water).

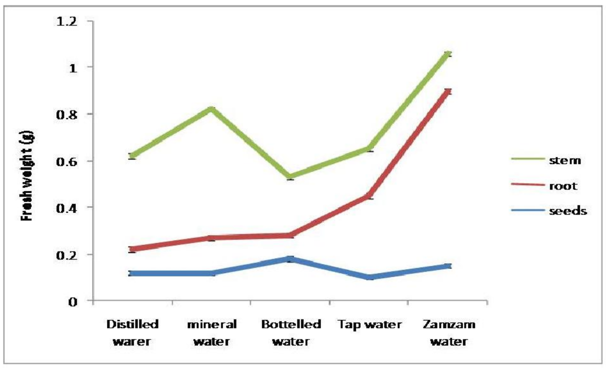

Figure 1: Seeds, root and stem fresh weight (g) **lentil (*Lens culinaris*)** seedlings grown with distilled water and other water types in Jeddah

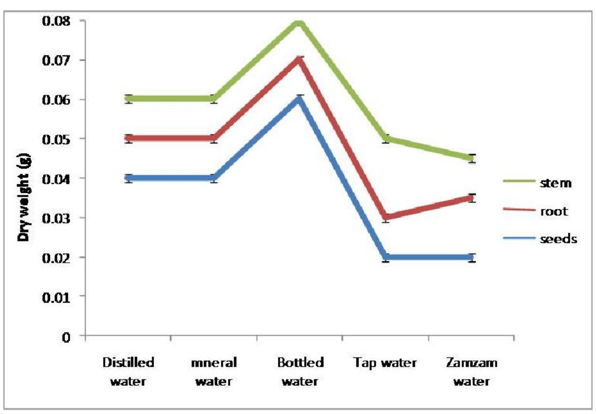

Figure 2: Seeds, root and stem dry weight (g) **lentil (*Lens culinaris*)** seedlings grown with distilled water and other water types in Jeddah.

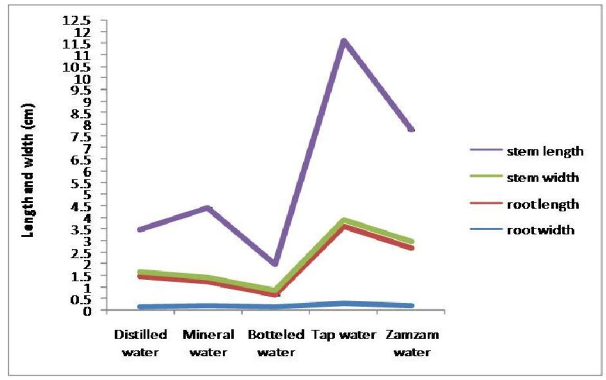

Figure 3: Root and stem length and width (cm) of **lentil (*Lens culinaris*)** seedlings grown with distilled water and other water types in Jeddah.

Pertaining to results of *Phaseolus vulgaris* plants which were demonstrated in Fig. 4, cotyledon weights were high in plants irrigated with different water types, excluding the control, which may be due to the low amount of minerals in this water especially in this stage of germination, as was reported by many authors e.g., Claire *et al*., (1991) ; Bishnoi, *et al*., (1993) ;Peralta *et al*., (2001) ; Lei *et al*., (2009) and Joshi *et al*., (2010). Irrigation with bottled water assisted *Phaseolus* plants to gain high cotyledon fresh weights (1.48 g). surprisingly, there was no significant difference in cotyledons fresh weight when plants were irrigated with mineral and Zamzam waters (1.41 g and 1.39 g) respectively.

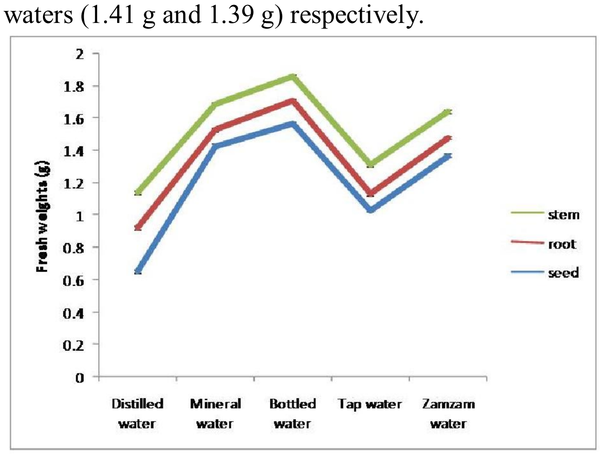

Figure 4: Seeds, root and stem fresh weight (g) ***Phaseolous vulgaris*** seedlings grown with distilled water and other water types in Jeddah.

Moreover, root and stem fresh weights reported no significant differences between different water types with the control reported slightly higher fresh weights. Nonetheless, Fig.5 illustrated that, cotyledons dry weights of *Phaseolus vulgaris* followed the pattern, according to water type, : bottled water > Zamzam water > mineral water > tap water > distilled water. Moreover, the highest stem dry weight was recorded when plants were irrigated with Zamzam water (0.39 g) compared to other water types ($P \leq 0.01$). On the other hand, high root dry weight was recorded in control and tap water plants while there was no significant difference among other treatments.

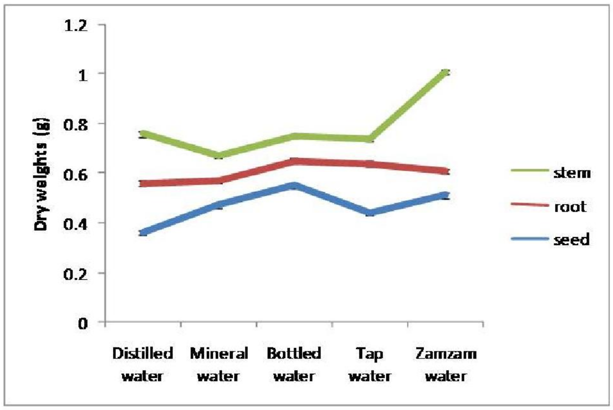

Figure 5: Seeds, root and stem dry weight (g) ***Phaseolous vulgaris*** seedlings grown with distilled water and other water types in Jeddah.

Root lengths of *Phaseolus vulgaris* (Fig.6), followed the pattern: distilled water> bottled water> mineral water> tap water> Zamzam water, while the stem length patterns was; mineral water> distilled water> bottled water>tap water.

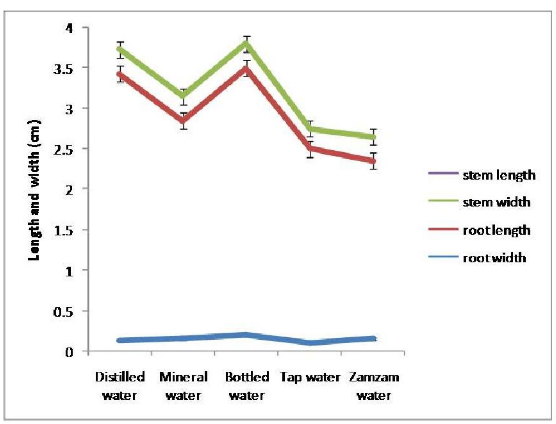

Figure 6: Root and stem length and width (cm) of ***Phaseolous vulgaris*** seedlings grown with distilled water and other water types in Jeddah.

In general, the present study has found that it would be possible to produce the food required in future using all water supplies available in Jeddah city. The more efficient water must be used more efficiently. SIWI, (2005) ;Chartres and Varma, (2010) have reported that farmers in dry regions have to strive to increase plant productivity to meet the growing demands for food.

This study, highlighted many facts concerning different water typed in Jeddah city. The chemical analysis of different water types indicated that all waters were not harmful in terms of heavy elements and they are below the national and international standard limits (Sayre, 1988; Wolf 2011; Sudhanandh, 2011 and The World Bank, 2011). In addition, water types pH ranged between slightly acidic (mineral and bottled water), to slightly alkaline (tap water and Zamzam water). These pH values are suitable for germination of many plants as was reported by many researchers, e.g. Demosthenis and Krishna (2002); Bhagirath *et al*., (2009), Shouhui *et al*., (2009); and Mercy et al., (2012). As the results revealed,electric conductivity, on the other hand, were relatively low in mineral, bottled and tap waters and slightly high in zamzam water. The Ec recorded values of Jeddah's waters did not affect germination of seeds of the two plants. Similar water Ec was found harmless to plants by other researchers, e.g. Al-Tukhais, (1997); Hsing *et al*., (2000); Dimitris, *et al*., (2005), Molden, (2007); Botto, (2009); Al-Rashed, (2010); Natale, *et al*., (2010) and Al-Sokary, (2011). The results indicated that low concentrations of Cr^{+6}, Cu^{+2}, and Ni^{+2} had micronutrient-like effects on the lentils and *Phaseolus vulgaris*. According to obtained data, the Zn^{+2} have positive effects on the growth of the plants, even at moderately high concentrations in this research.

Conclusion:

Being a desert country with a growing population, alternative water supplies imperative for the development of agriculture in Saudi Arabia. In addition, according to the present study one can speculate about getting benefits from the huge amount of Zamzam water to be used in agriculture after careful handling and storing.

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