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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2017 14(3): 582-591. **OPEN ACCESS**

Assessment of waste water quality for use in crop production: case studies of Al Gabal Al Asfar Waste water Treatment Plant (*WWTP*)

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Field experiments were conducted in winter season in two sites located north east of Cairo, Al Gabal Asfar to appraise the collision of short – term use of treated wastewater and well water on growing oil and cereal winter crops. The use of wastewater and well water for growing three oil winter crops (Rape, Lettuce and Flax) and two-cereal winter crops (Wheat and Barley) were inquired. Results evinced that irrigating soil with wastewater gradually improved soil characteristics as compared with well water. Higher heavy-metal accumulation in soils irrigated with wastewater as compared with well water was observed. At crop harvest, the organic carbon content was gradually increased. Consequently, the most crucial change was slightly decreasing soil pH from 8.85 to 8.1 within few months. Application of wastewater effluent stimulated the yield characteristics of oil and cereal winter crops as compared with well water. Dramatically increased of growth parameters and yield components for plants irrigated with wastewater as compared with those irrigated with well water. It is worthy to note that all oils extracted from harvested seeds under irrigation with wastewater effluent were free from potential toxic element

Keywords: oil and cereal crops-irrigation-wastewater-nutrient contents- oil production

INTRODUCTION

Egyptian government is attentive in advancing the cultivated area. The most of ambition areas are discover in hot dry regions, suffering from drought condition. Under such conditions, the availability of fresh water for irrigation is limited, which restricts the possibility for increasing the cultivated area McNeill *et al*., 2009 and Khurana and Singh, 2012). Agriculture researches and scientists are interest to develop methods of water supplies. Using less amount of fresh water as far as possible, Darvishi *et al*., (2010); Tunc, and Sahin, (2015) and Becerra-Castro, *et al.,* (2015) .In some cases, reappearing well-treated water to rivers might provide better substances that can be pollutants when discharged to waterways outcome than reuse by irrigation to supplement river flows. This guideline will however help increase the options available for water management, particularly those sources of wastewater that are not acceptable or requisitely treated for safe discharge to rivers. Many water needs; can be satisfied with recycled water as long as it is adequately treated to ensure water quality is appropriate for the proposed use. Furthermore, reuse of wastewater as a source of irrigation may reduce fertilizer applied rates and accommodate a low cost of irrigation water as well, treated municipal wastewater have been successfully used for irrigation of various crops including agronomic and horticultural crops. Khurana, and Singh (2012), Raju, et al, (2015), and Mojid, et al, (2016).

Due to high nitrogen, phosphorus and potassium contents in wastewater, it considered as low price fertilizer, Kumar, et al, (2014) and Bedbabis et al, (2015). The objective of this research is to investigate the short – term use of wastewater and well water for growing oil and cereal winter crops.

MATERIALS AND METHODS

Field experiments were carried out at Al Gabal Al Asfar wastewater treatment plant (WWTP) to fulfill the objective of the present study, the properties of the soil was sandy loam, characterized by pH - 7.85, E.C - 0.43 $dS.m^{-1}$, O. M - 0.85%, and $CaCO_3$ was 1.65%. First experiment was carried out using, wastewater as source of irrigation without any fertilizers rates addition. Second experiment was irrigated with well water with the recommended doses of fertilizers applied. Nitrogen fertilizer was added at three equal portions and potassium fertilizer at flowering stage; however, phosphate fertilizer was amalgamated with soil prior to sowing

The experimental areas were rideged into sufficient numbers of experimental plots, each 30 m^2 and carried out in a complete randomized block design with four replicates.

Seeds of oil lettuce, flax (Giza 8), rape (Orba), wheat and barley were sown. All agricultural practices were ensued as approved by Ministry of Agriculture and Land Reclamation. Table 1 summarized some chemical analyses of both types of irrigation water.

After harvesting, soil samples were collected to determine chemical and biological changes. Plants were collected from each experimental plot, yield and its components per plant were calculated, macro- and micronutrient contents of investigated plants and physical and chemical properties of the soil were determined using methods described by Cottonie et al, (1982). Extraction of essential oil, (50 g.) of seeds was subjected to Hydro distillation for 1h using a Clevenger type apparatus (Clevenger1928). Constituents of essential oil were determined by the method described by (Adams1995).

Table. 1. Some chemical and physical properties of wastewater and Well water

Treatment	Parameter	Nutrient element (mg/l)						
	pH	**N**	**P**	**Na**	**K**	**Ca**	**Mg**	**Cl**
Wastewater	8.1	25	8.23	86	15.3	54	17	72
Well water	8.4	5	0.3	94	16.2	65	18	79
permissible limits	-	-	-	-	-	-	-	300
	E.C dS/m	**Fe**	**Zn**	**Mn**	**Cu**	**B**	**Pb**	**Cd**
Wastewater	1.2	0.026	0.015	0.01	Traces	0.23	0.05	0.004
Well water	1.4	Traces	Traces	Traces	Traces	0.13	0.04	0.005
permissible limits	4	5	2	0.2	0.2	3	5	0.01

RESULTS

Chemical properties of soil as affected by both wastewater and well water

Irrigation of sandy loam soil at both experimental sites, with either treated wastewater effluent or well water, led to appraisable changes in soil properties (Table 2). Results indicated that irrigation soil with treated wastewater effluent, improved soil properties as compared with well water. Data in Table (2) illustrated that investigated soils used were poor in their chemical and physical properties. However, wastewater effluent or well water irrigation tended to increase the soil nutrient contents. Similarly were, obtained by Nadav et al, (2013) who illustrated that prolonged of wastewater application gradually enriched the nutrients content as well as accumulation of organic matter in the soil profiles The frequented changes during the experimental period, owing to, the nutrients added through the irrigation frequency by both application of wastewater and chemical fertilizers added through the irrigation with well water, and or those absorbed by growing crops. Results indicated that a positive balance was distinct with treated wastewater effluent and a negative one was retained with well water. Conspicuous trend of soil amelioration was unconfused throughout irrigation with treated domestic sewage effluent. The organic carbon content was magnified from 0.252% to 0.673 at crop harvest. Consequently, the most critical change was shifting of soil pH from 8.85 to 8.1 during the growing season.

Table (2) Changes in soil properties irrigated with treated wastewater or well water

Soil property	Soil irrigated with wastewater		Soil irrigated with well water	
	Initially	At harvest	Initially	At harvest
pH (1: 2.5)	8.85	8.1	8.2	8.25
E.C (ppm)	375.0	432.0	272	220
Organic C%	0.252	0.673	0.23	0.16
Total N %	0.01	0.09	0.01	0.01
Total p %	0.03	0.04	0.04	0.02
Total k %	0.134	0.119	0.039	0.028
Total Fe %	0.95	1.05	0.42	0.56
Total Zn ppm	20	26	10	12
Total Mn ppm	160	132	77	86
Total Cd ppm	2.32	2.66	1.35	1.22
Total Cr ppm	23.11	20.1	20.5	16.3
Total Pb ppm	3.9	2.15	4.21	2.39

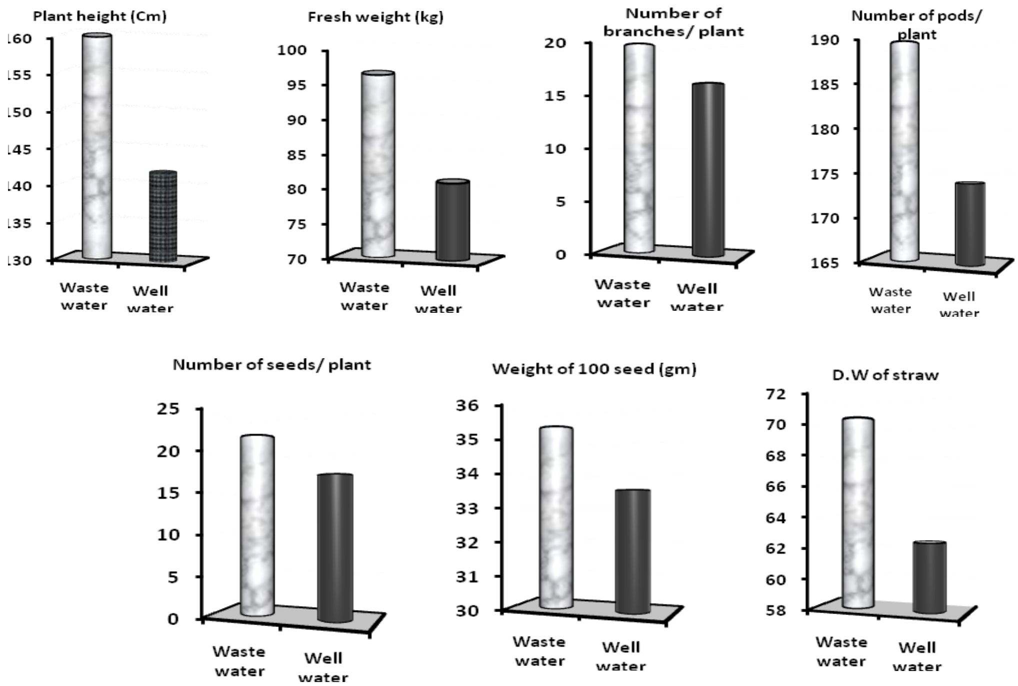
This phenomenon may be related to the beneficial effect of the organic material creating from irrigation itself. Soil organic carbon (OC) has been the exclusive indicator of soil quality as it acts as a store of plant available nutrients Abou Seeda et al, (1997**).** Several researchers stated that prolonged of wastewater treated soil gradually increased the organic matter content, particularly, in the top soil Singh, et al, (2011) and Christou et al, (2014).

Table (2) illustrated that prolonged of wastewater application stimulate the accumulation of macro-and micro-nutrients in soil as compared with well water. Remarkable increase of total heavy metals particularly, in surface soil layer has been observed. Ale et al, (2008). The accumulation of heavy metals in the surface soil may be resulted from sorption reactions of negatively charged soil colloids for these cationic heavy metals Lin, et al, (2008).

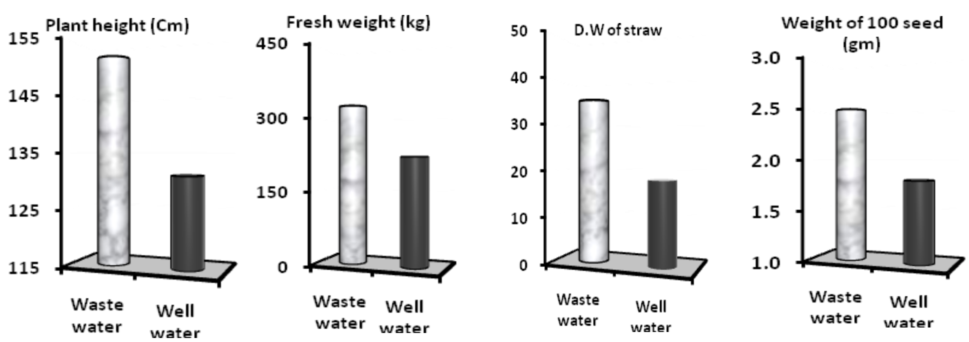
Dheri et al, (2007**)** stated that large quantities of OM from wastewater and anaerobic conditions developed, due to heavy loading of OM had reduced OC decomposition and resulting in build-up of soil OC. Therefore, long-term of wastewater irrigation can be a good means of carbon sequestration in soil and can thus, be referred as a soil quality sustaining practice

Yields characteristics and their components of oil and cereal crops as affected by irrigation with wastewater and well water

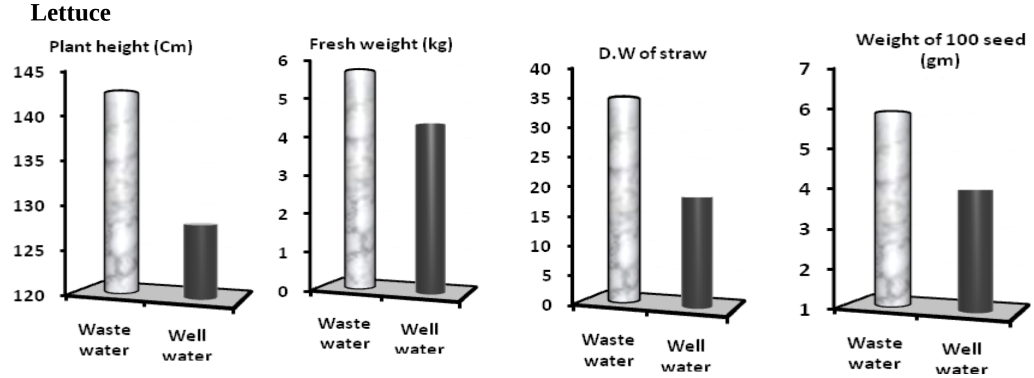
Yields characteristics and their components of oil and cereal crops are illustrated in Figures (1 and 2). Results showed that application of wastewater effluent stimulated the yield parameters as compared with well water**.** Biswas et al, (2015) observed that low cost filter municipal waste water as a source of irrigation gradually, stimulated the growth yield of lettuce and red amaranth plants as compared with the control one (water from ponds and river). Golchin et al, (2013) indicated that using of wastewater could improve morphological characters, yield and its components of alfalfa as compared to control one. Qaryouti et al, (2015) reported that, untreated waste effluents for irrigation, significantly increased plant parameters of both tomato and cucumber crop. Data indicated that irrigation with wastewater stimulated the yield parameters. Average of increase in plant height for rape, lettuce, flex, wheat, and barley were 12.7%, 16.0%, 11.7%, 6.70% and 6.33% as compared with well water, respectively. Data also illustrated that wastewater effluent stimulated the grain yield of rape, lettuce, flex, wheat, and barley by about 5.67%, 39%, 50%, 44.9 % and 9.3% as compared with well water, respectively



Rape

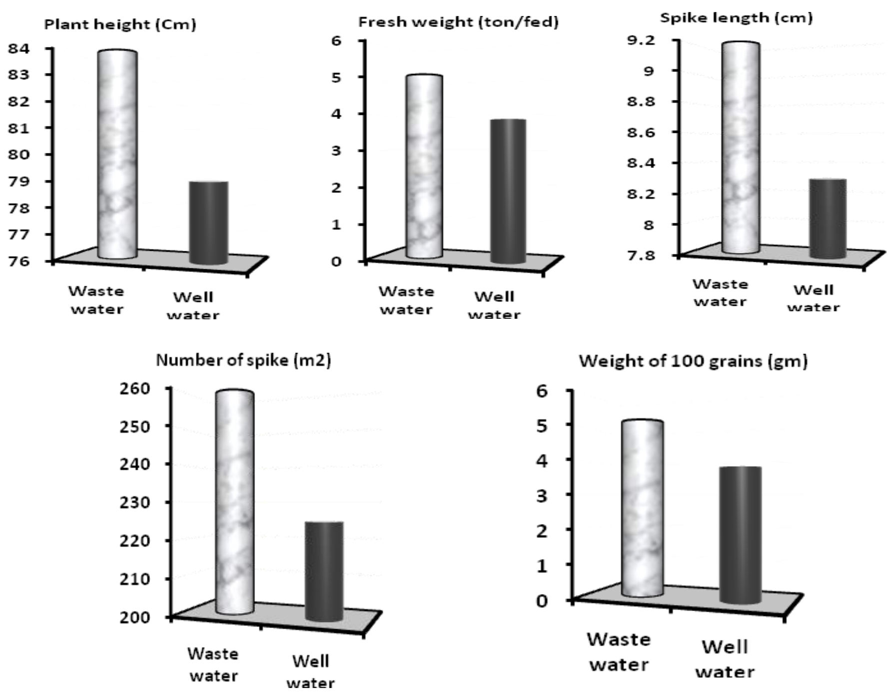


Lettuce

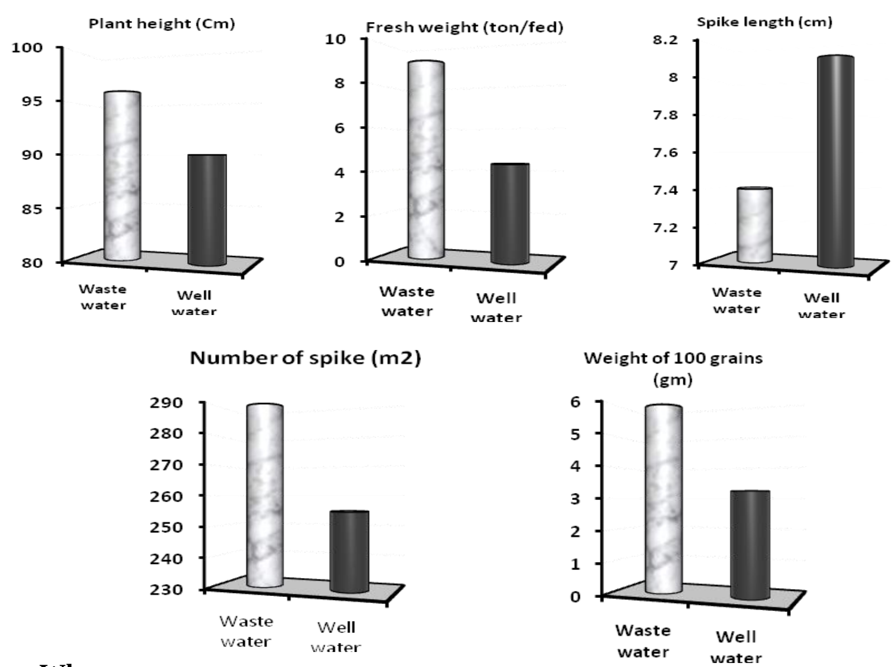


Flax

Fig (1): Effect of wastewater and well water as a source of irrigation on yield parameters of oil crops



Barley



Wheat

Fig (2) Effect of wastewater and well water as a source of irrigation on yield parameters of barley and wheat crops

Application of wastewater gradually increased number of branches and pods for rape by about 25%, 9.20% as compared with well water. The number of spike also increased by about 13.7% % and 15.5% for wheat and barley, respectively. This result may be due to wastewater that considered as low price fertilizer due to its high nitrogen, phosphorus and potassium contents, (Kumar and Chopra 2013 , Kumar, et al, 2014 and Bedbabis et al, (2015).Gupta et al, (2015) indicated that in field experiments, using of wastewater as source of irrigation, increased plant height, number of leaves per plant, leaf area index, leaf to stem (green and dry) biomass and green fodder yield were also noticed. Macronutrient contents as affected by wastewater and well water irrigation Fig (4) showed macronutrient contents as affected by irrigation with wastewater and well water. Data observed that application of wastewater gradually increased the total nitrogen, phosphorus and potassium contents in both oil and cereal crops. Average of increases were 4.3%, 10.2%, 29.2%, 16.1%, 19% and 10%, 17.6%, 16.7%, 27.6%, 20.5% and 8.1%, 11.5%, 17.7% 27.3% and 9.9% for rape, flex, lettuce, wheat and barley, respectively. This phenomenon probably due to the initial nutrient contents in the wastewater effluent, Nissim *et al.,* (2015) reported that wastewater can be consider as nutrient-rich and can reduce the recommended of chemical fertilizers, they also reported that application of wastewater dramatically increased total, inorganic and organic phosphorus on the surface soil.

Heavy metal contents in oil and cereal crops as affected by irrigation with wastewater and well water.

Effect of wastewater and well water on heavy metal contents in rape, flax, lettuce, wheat and barley are presented in Fig (5). Results indicated that wastewater gradually stimulated the heavy metals contents as compared with well water. Wastewater effluent resulted in a remarkable effect on Fe, Mn, Zn, Cu. Average of increases were 6.2 %, 21.4%, 19.7% ,5.9 % and 5.1%, for Fe and 22.2 %, 12.0%, 27.6% ,16.7 % and 10.5%, for Zn and 20.8 %, 18.8%, 9.8% ,19.5 % and 10.0%, for Mn and ,for Cu, were 13.1 %, 7.8%, 7.8% ,8.1 % and 22.8% rape, flex, lettuce, wheat and barley, respectively.

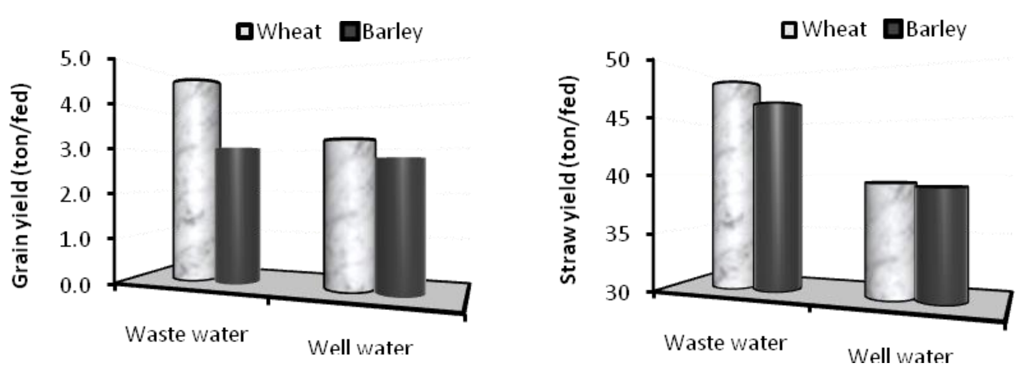


Fig (3) productivity of wheat and barley (Grain and Straw)

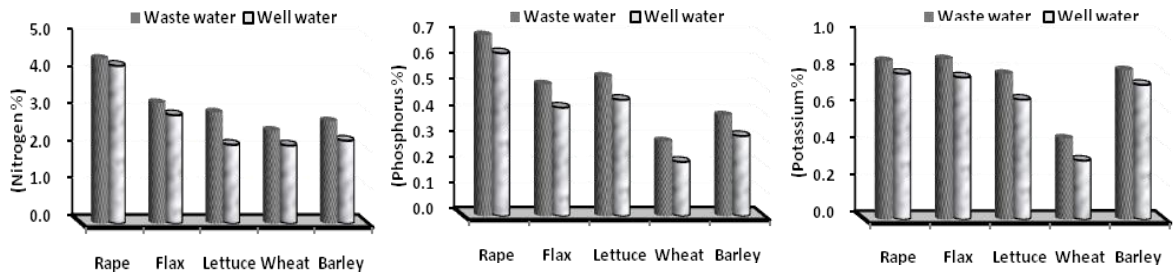


Fig (4): Macronutrient contents as affected by irrigation with wastewater and well water

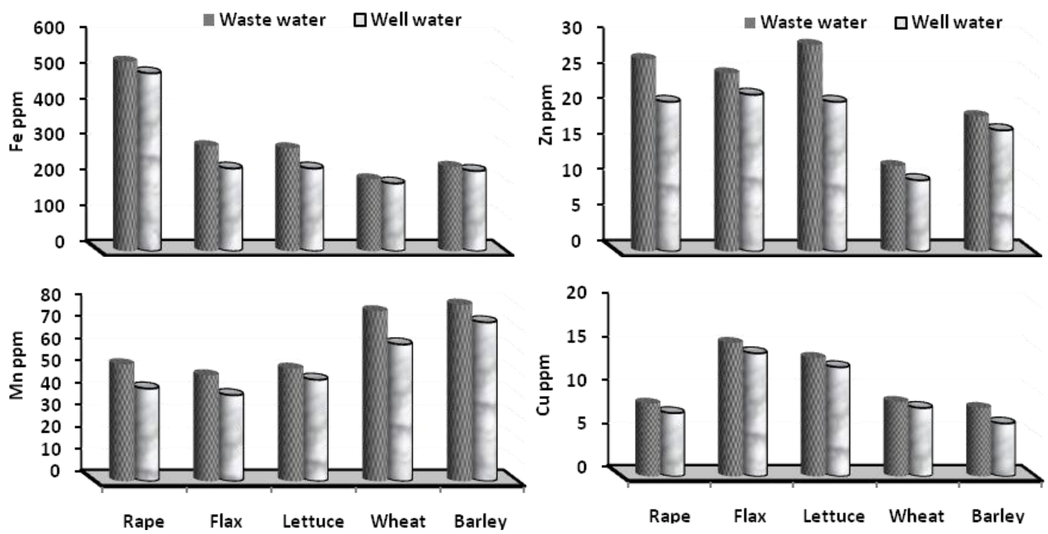


Fig (5): Micronutrient contents as affected by irrigation with wastewater and well water

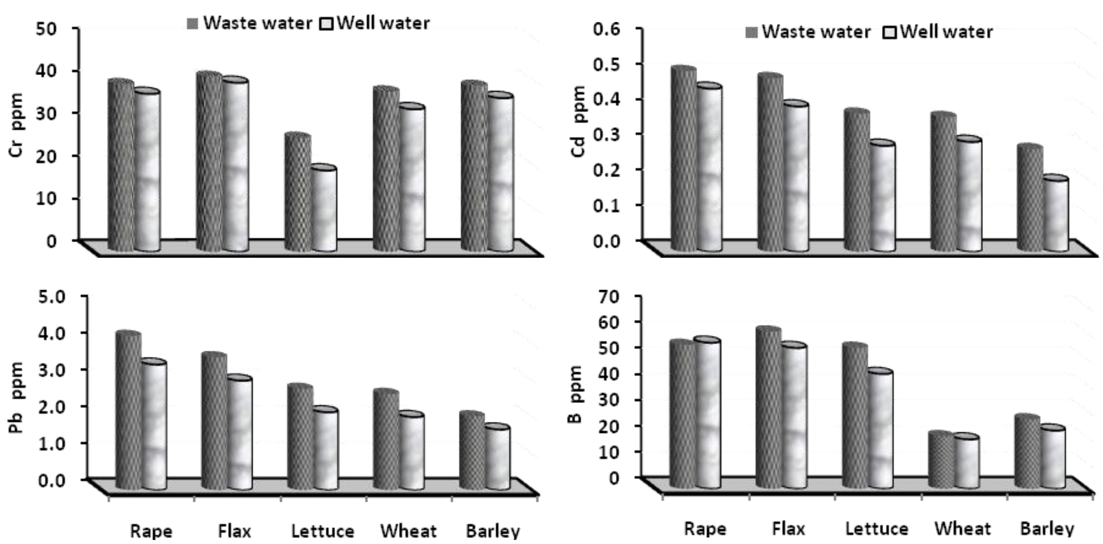


Fig (6): potential toxic element contents in seeds grown under irrigation with wastewater and well water

Generally, in contaminated areas accumulation and absorption of heavy metal by plants followed the order of magnitude of greater availability in the surrounding medium. Dheri et al, (2007) reported that direct relationships between heavy-metal contents and uptake by plants. The concentration of heavy metals in plants showed direct significant relationship with heavy-metal concentrations in the waste effluents. Even the different plant parts of same species completely differed appreciably from one-another in their ability for absorption, translocation and accumulation of heavy metals and micronutrients Nawaz et al, (2006).Fig (6) showed the potential toxic element contents as affected by irrigation with wastewater and well water. Application of wastewater effluent resulted in a remarkable increase of Cr, Cd, Pb and, B.averageof increases for rape, Flax, and lettuce were 5.9%, 9.8% ,18.6 % and -1.4%, 3.4%, 16.3%, 17.7 % and 10.5% , 28.6%, 23.3%, 23.2 % and 18.6 %, respectively. Data also indicated that average of increases for both wheat and barley were 11.1%, 18.4%, 24.0 % and 6.1%, 7.3%, 31.0 %, 17.9 % and 16.3%, respectively Oil yield and oil percent of rape, lettuce and flex seeds as affected by irrigation of wastewater and well water . Data presented in Fig (7 and 8) indicated that application of wastewater gradually increase the percentage of oil. Oil percentages were higher in seeds of flax and lettuce plants irrigated with wastewater as compared with well water. Bourazanisa *et al*., (2015) indicated that wastewater irrigation gradually increased the oil content in olive trees and yield oil fed^{-1} due to the higher dry weight at harvest. In case of rape plants, evinced higher oil content in the seeds of plants irrigated with well water was also observed. It is worthy to note that all oils extracted from harvested seeds under irrigation with wastewater effluent were free from potential toxic elements. The recorded dispirited in potential toxic elements content among the different tested plants are authorized to the different nature of absorbing nutrient from soils

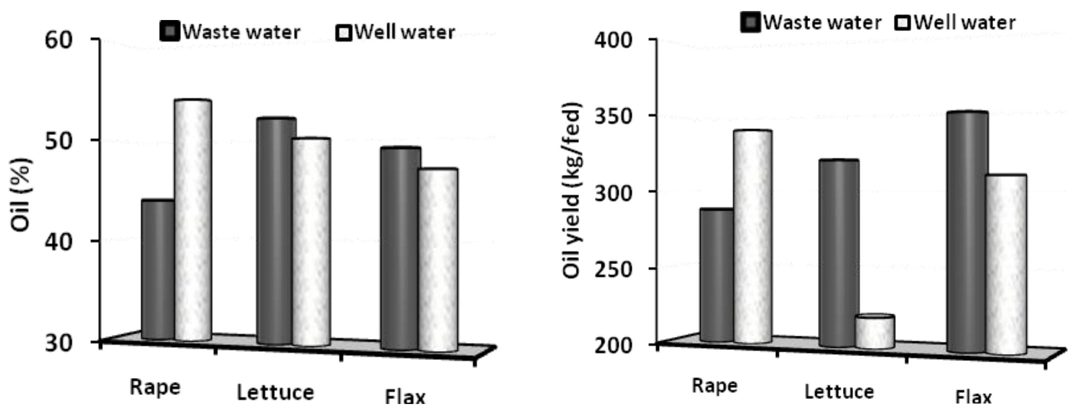


Fig (7) Effect of wastewater and well water irrigation on oil yield and oil % in seeds of flax, lettuce and rape crops

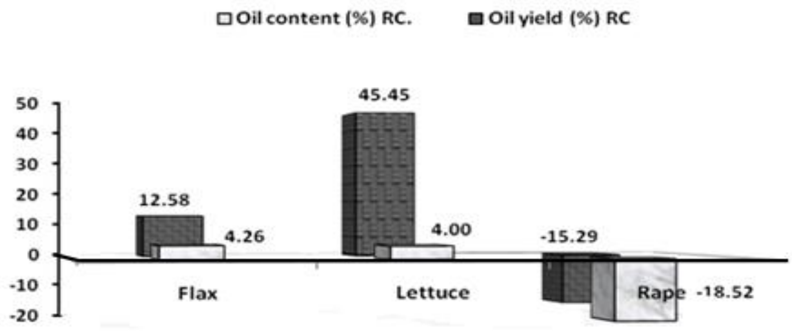


Fig (8): Seed oil (%) and oil yield expressed as (RC) with both wastewater and well water irrigated soil

CONCLUSION

It could be concluded that application of wastewater effluent stimulated the yield characteristics of oil and cereal winter crops as compared with well water.

CONFLICT OF INTEREST

The authors declared that there was no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors contributed to the design of the experiments AMA preformed the experimental work , YAA and AEAA carried out laboratory and statics analysis., AMA and AEAA wrote the manuscript, all authors revised and approval the final version.

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