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Influence of Waste Water used in Irrigation on the Physical Properties of Olive Oil in Palestine

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Abstract

In this study, olive oil samples of different irrigation system of different regions in Palestine were studied. The density, refractive index, acidity and viscosity of the samples were measured. The acidity of olive oil samples from different location and different irrigation system was measured. The overall results indicate that acidity increase for samples their trees were irrigated by waste water and classified to Lampante oil, and most of the olive oil samples are classified to be ordinary virgin oil. The viscosity of olive oil samples of 2014 crop from different regions was studied. The experimental results of viscosity showed that the viscosity increased for samples were irrigated by waste water. The concentration of some metals in olive oil samples irrigated by waste water was found to be highly concentrated compared with literature values of metals.

Keywords: Irrigation; Physical properties; Viscosity

Introduction

Olive trees are one of the perennial trees which were planted by early humans beside trees of date like grapes and figs since early Bronze age [1,2]. Olive oil is edible oil, which is known as one of the components of Mediterranean diet along with fruits and vegetables. Olive production is spreading over worldwide [3-5].

Olive oils are used to lower the possibility of having certain kind of cancer, such as colon disease along with other diseases, and are used in making different kinds of ointments [5-7].

Olive oil quality are affected by many factors such as climate, nature of water used for irrigation of olive trees, fertilizing applications, processing equipment, period of repining their fruit and other factors [8,9]. Trace elements which are found in the natural environment, some hazardous to organisms and other are used in life [10]. Some of the trace elements include copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe) which are essential for plant growth [11].

Other trace elements like cadmium (Cd), lead (Pb), chromium (Cr), nickel (Ni), mercury (Hg) and arsenic (As) have the toxic effect for all living organisms even if they are used in small quantities and stored at low concentration for long time periods [11,12]. Many articles have been published to describe the relevance between cancer disease and specific trace elements such as cadmium (Cd), selenium (Se), arsenic (As) and other elements which they are toxic.

Trace elements may be analyzed by using inductively coupled plasma-optical emission (ICP-EOS) systems which dominates the inorganic analysis landscape [13].

Other trace elements such as Ca, Fe, Mg, Na and Zn that were found in olive oil, have been studied by using ICP – AES technique, which was used by Zeiner when he made a pilot study on the geographical characterization and found the concentration of trace elements [5]. Trace elements which are found in different types of oil due to the influence of human health and nutrition, transports from agro eco system to the environment [11].

Many reports described the harmless effect that trace element have on oil when the trees were irrigated with waste water. This is because of the presence high concentration of micro organisms such as bacteria, fungi, viruses, helminthes and heavy metals which are found in wastewater such as arsenic, copper, cadmium, lead, chromium, nickel, mercury and zinc [14-16]. Bedbabis has noticed high concentration of heavy metals Zn and Mn only after the second year of irrigation, during his study the effect of irrigation with treated wastewater on olive trees grown in arid region in Tunis [17].

Segal studied the effect of reclaimed water that is used for irrigation on the growth of olive trees. He found that the concentration of some metals in each of the reclaimed water and fresh water differs and the highest concentration of these metals is observed in reclaimed water [18].

In this work, the concentrations of metals in edible olive oil from different locations in Palestine and different irrigation system are determined by ICP-MS. We propose a relationship between metal concentration in edible olive oil and irrigation system of the edible olive oil.

Experimental

Sample collection

The olive oil samples used in this study were collected from different irrigation system (rain water, pure water, reclaimed waste water and waste water) for different Palestinian regions of crops 2013 and 2014

The entire samples were kept at the same conditions at room temperature in dark place and packed in closed plastic bottles.

Apparatus and methods

The trace element of olive oil samples were determined by using ICP – MS (Perkin Elmer Elan 9000) device, for different irrigation system from different region in Palestine for the crops of 2013 and

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2014. The physical properties for the samples of olive oil measured by: NDJ-1 Rotational Viscometer to measure the viscosity, the Pycnometer for determines the density, digital Refractometer to determine the refractive index, and acid value of olive oil which was measured by using (Titrimetic method). And the temperature of olive oil samples was estimated using Digital prima long thermometer.

Results

Physical properties of different samples according to their irrigation system

Density results: The densities of different olive oil samples were measured at 20.0°C of crops 2013 and 2014, and compared with codex standard are given in Table 1 [19,20]. The average density in gm/cm^3 of olive oil samples (S_{1b}) for the crops of 2014 is 0.9169 gm/cm^3 compared with crops of 2013 which was 0.9161 gm/cm^3. The highest value of measured density is 0.9205 gm/cm^3 for sample S_4, which their trees were irrigated by wastewater of crop 2014 and it is greater than standard value (0.910-0.916) gm/cm^3. The lowest values of measured densities were 0.9161 gm/cm^3 for sample S_{1a} which their trees depend on rain water, and it is in good agreement with standard value (0.910 -0.916) gm/cm^3. The density increases for irrigated samples by waste water compared with samples irrigated by rain water.

Viscosity results: The viscosity of olive oil samples decreases with increasing temperature, this is because when the temperature increases it causes to decrease the inter-molecular forces between the nearest neighbors molecule of samples. The measured results for the viscosity of olive oil samples were measured at 20.0°C of crop 2014 are given in Table 2. The viscosity of samples which their trees irrigated by waste are greater than viscosity of other irrigation system.

Refractive index results: The measured refractive index for all olive oil samples were measured at room temperature 23°C, of two different crops 2013 and 2014 and compared with standard value are given in Table 3 [19-21]. The measured refractive index of samples which irrigated by waste water, reclaimed waste water and pure water are greater than samples that depends on rain water.

Acidity results: The acidity represents an important parameter for oil classification. Table 4 gives the categorization of olive oil quality according to their acidity [3,20-22].

The acidity results of olive oil samples of two different crops 2013 and 2014 from different location were measured. The measured values are given in Table 5. The classification of olive oil sample is given according to Table 4.

Table 5 shows most of olive oil samples from different location are differ in their acidity. Samples S_{1b} for crops of 2014 are virgion olive oil, while samples (S_2 and S_3) of crop 2014 and sample (S_{1a}) of crop 2013 are forms ordinary virgion olive oil while S_4 are Lampante oil. The acidity of olive oil affected by different factors such as method and period of storage oil, cultural techniques employed for oil extraction and may be type of irrigation used.

The measured values of acidity of olive oil samples from different location are plotted in Figure 1.

Figure 1 shows that the acidity for samples which their tress irrigated by waste water are greater than other samples, this means the acidity increases when waste water uses.

The results for acidity of olive oil sample can be used to determine the quality of olive oil which various between virgin for samples depend on rain water, ordinary virgin for irrigated samples by reclaimed waste water and Lampante oil for irrigated samples by waste water. The classification of olive oils is due to their acidity according to Table 4.

Trace elements

The results for metals concentration of olive oil samples for different sites according to their irrigation system of crops 2013 and 2014 are given in Table 6. The determination of trace metals in olive oil samples by using ICP – MS can be used for the characterization of oil quality by estimating the concentration of metals, which shows difference for each oil concentration according to their irrigation system.

Region	Sample	Type of Irrigation	Crops	Our Density	Codex Standard
Hawara and Misseli	S_{1a}	Rain water	2013	0.9161	0.910 - 0.916
Hawara and Misseli	S_{1b}	Rain water	2014	0.9169	
Shillo	S_2	Pure water	2014	0.9179	
Anabta	S_3	Reclaimed waste water	2014	0.9198	
Deir Sharaf and Brouqn	S_4	Waste water	2014	0.9205	

Table 1: The measured mass density in (gm/cm^3) of olive oil for different samples at 20.0°C compared with codex standard.

Region	Sample	Type of Irrigation	Crops	Viscosity
Hawara and Misseli	S_{1b}	Rain water	2014	69.5
Shillo	S_2	Pure water	2014	72.3
Anabta	S_3	Reclaimed waste water	2014	73.2
Deir Sharaf and Brouqn	S_4	Waste water	2014	80.4

Table 2: The measured viscosity in cP of olive oil for different samples at 20°C.

Region	Sample	Type of Irrigation	Crop	Refractive Index	Codex Standard
Misseli and Hawara	S_{1a}	Natural water	2013	1.4656	1.4677 - 1.4706
Misseli and Hawara	S_{1b}	Natural water	2014	1.4665	
Shillo	S_2	Pure water	2014	1.4671	
Anabta	S_3	Reclaimed wastewater	2014	1.4670	
Deir Sharaf and Brouqen	S_4	wastewater	2014	1.4671	

Table 3: Our measured refractive index of olive oil of different samples at 23.0°C compared with standard value.

Category	% FFA
Extra Virgin olive oil	≤0.8
Virgin olive oil	≤2.0
Ordinary virgin olive oil	≤3.3
Lampante oil	>3.3

Table 4: Categorization of olive oil quality according to % FFA.

Region	Type of Irrigation	Sample	Crops	Acidity	Olive Oil Classification
Misseli and Hawara	Rain water	S_{1a}	2013	2.34	Ordinary virgion olive oil
Misseli and Hawara	Rain water	S_{1b}	2014	1.85	Virgion olive oil
Shillo	Pure water	S_2	2014	2.73	Ordinary virgion olive oil
Anabta	Reclaimed waste water	S_3	2014	3.03	Ordinary virgion olive oil
Deir Sharaf and Brouqen	Waste water	S_4	2014	3.35	Lampante oil

Table 5: The acidity results and classification of olive oil samples of two different crops 2013 and 2014.

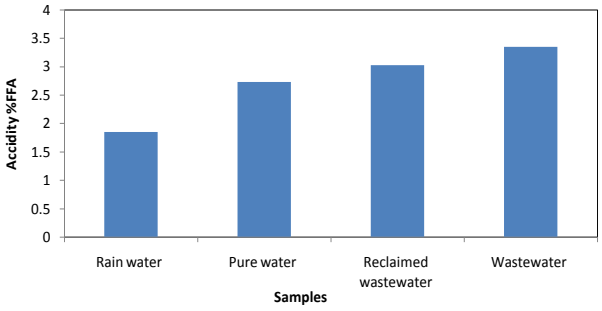

Figure 1: The relation between acidity and type of samples according to their irrigation system of crop 2014.

Metal	Rain Water of 2013	Rain Water of 2014	Pure Water of 2014	Reclaimed Waste Water of 2014	Waste Water of 2014
Ca	1164.8250	1110.6730	949.0872	1317.1110	1836.8490
Cd	0.0778	0.0898	0.0036	0.0108	0.0110
Co	0.0408	0.0198	0.0124	0.0140	0.0202
Cr	2.6076	2.1432	2.1632	2.1028	2.1116
Cu	1.4352	1.1830	1.1058	1.4316	1.7400
Fe	33.8176	26.9542	22.2520	25.7286	43.4490
K	25.9488	22.7490	15.4688	21.2264	38.6888
Mg	257.2330	301.3100	270.6774	519.0152	637.9324
Mn	0.7702	0.4830	0.2644	0.4324	0.6836
Na	234.8748	171.4816	115.8286	225.2206	247.9686
Ni	0.7512	0.2754	0.0892	0.1784	0.2890
Pb	1.6348	3.5768	0.5182	0.8388	0.6818
Zn	13.4984	8.0478	7.4032	11.3044	23.7126

Table 6: Results for metals concentration (µg/g) in olive oil samples, which they were measured by using ICP – MS for different irrigation system.

Calcium (Ca): Calcium is a useful metal for building bones and teeth for human body, a lake of calcium can cause osteoporosis dieses [23]. The concentrations of Ca according to their irrigation system were shown in Figure 2.

The Figure 2 shows that the (Ca) content of the samples ranged from 949.0872 to 1836.8490 µg/g, Shillio site which their trees irrigated by pure water had the lowest concentration whereas Brouqen which their trees were irrigated by waste water had the highest concentration. The concentrations of calcium in this study are greater than previous studies.

Sodium (Na): Sodium is an essential trace element and its required for body in a determine concentration, where the highest concentration of Na that causes high blood pressure [24]. The concentration of Sodium according to their irrigation system, were shown in Figure 3. The highest concentration of Na for sample S_4 which their trees irrigated by wastewater is 247.9686 µg/g, but the lowest value of sample S_2, their trees irrigated by pure water as shown in Figure 3. The concentration of sodium in all our samples is higher comparing with previous studies.

Potassium (K): The bodies need potassium to build muscle and control the electrical activity of the heart, but if potassium takes at high concentration it can cause abnormal heart disease [24]. The concentrations of potassium according to their irrigation system were shown in Figure 4. The maximum value of K is 38.6888 µg/g for samples their trees irrigated by wastewater, while the minimum value is 15.4688 µg/g for sample S_2 from Shillio site which their trees irrigated by pure

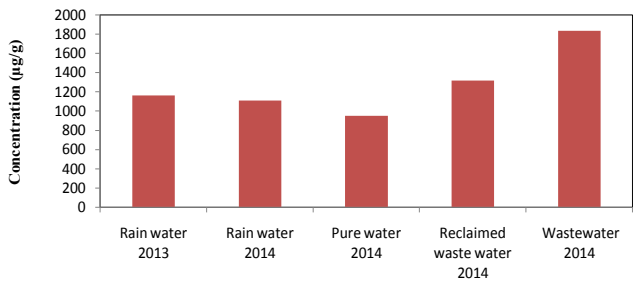

Figure 2: Concentration of Calcium in olive oils for all sampling sites according to their irrigation system of crops of 2013 and 2014.

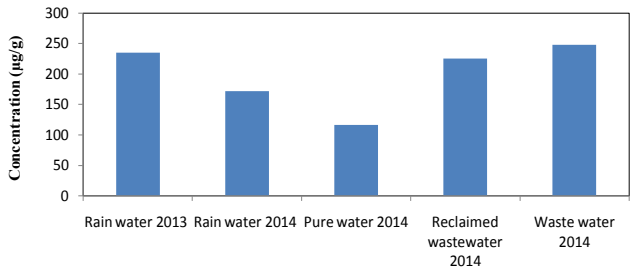

Figure 3: Concentration of Sodium in olive oils for all sampling sites according to their irrigation system of crops of 2013 and 2014.

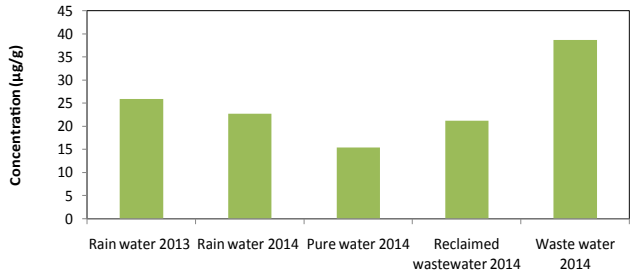

Figure 4: Concentration of Potassium in olive oils for all sampling sites according to their irrigation system of crops of 2013 and 2014.

water. The results for the concentration of potassium metals are greater than previous studies.

Magnesium (Mg): Magnesium is one of essential elements for human body and needs in high concentration compared to other metals. The concentrations of magnesium according to their irrigation system were shown in Figure 5. The Figure 5 shows that the highest concentration of Mg for the samples that had trees that were irrigated by wastewater and reclaimed waste water in the range between 257.233 upto 637.9324 µg/g which is greater than the concentration of previous studies.

Iron (Fe): Iron is an essential metals for humans body, because it contains number of protein, enzymes and having hemoglobin and transports oxygen through blood for all tissues in human body [24]. Each 450-500 ml of human blood contents 200-250 mg of iron.

The maximum concentration for iron is 100 mg per day. If iron is taken at low concentration it can cause anemia disease while the high concentration can damage tissues [25]. Iron increases the absorption of Cd, Pb, Al [26]. The concentrations of iron according to their irrigation system were shown in Figure 6.

Figure 6 shows the maximum value for iron metal in the measured concentration is 43.449 µg/g for samples which their trees were irrigated by wastewater of crop 2014, and this measured value is greater than the standard value 3 µg/g for IOOC [27].

Cadmium (Cd): Cadmium is a very toxic trace metal which it's spread through blood, and interacts with zinc. The concentrations of cadmium according to their irrigation system were shown in Figure 7. The highest Cd concentration in olive oil sample was 0.0898 µg/g where the lowest value was 0.0036 µg/g for sample S_2 which their trees irrigated by pure water as shown in Figure 7. The measured values of Cd concentration in all olive oil samples lower than standard value.

Cadmium particles released into air because of its use in various industries and emitted from car exhaust gases, where Hawara town is considered an industrial area and movement of cars. So because of

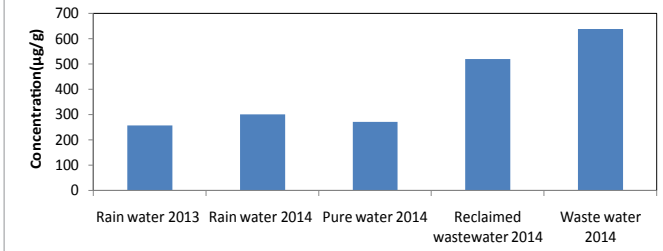

Figure 5: Concentration of Magnesium in olive oils for all sampling sites according to their irrigation system of crops of 2013 and 2014.

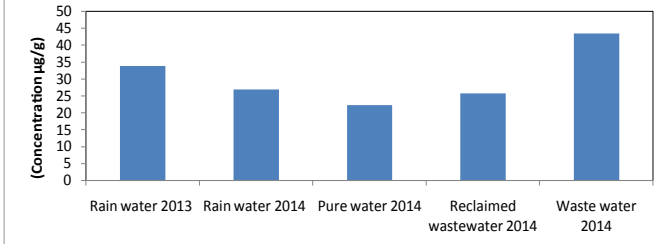

Figure 6: Concentration of Iron in olive oils for all sampling sites of crops of 2013 and 2014.

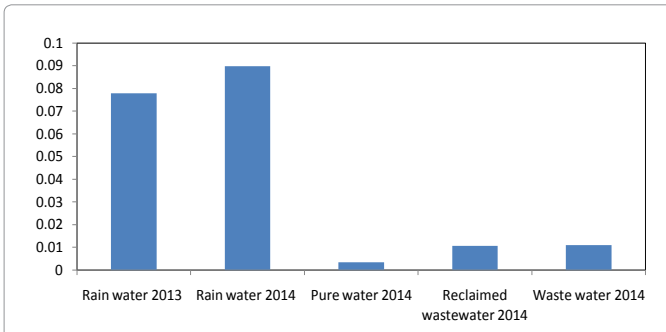

Figure 7: Concentration of Cadmium in olive oils for all sampling sites of crops of 2013 and 2014.

these reasons the high concentration of cadmium for sample S_2 which it from Hawara town and their trees depend on rain water.

Copper (Cu): Copper is one the main important elements for human body which plays an essential rule for producing enzymes and is essential for biological activities [28]. Cu is a very toxic If it is taken at high concentration it can causes many problems for human such as damage brain [29,30]. The concentrations of copper according to their irrigation system were shown in Figure 8.

The copper content was measured in the range from 1.183 - 1.740 µg/ g, the measured values are greater than 0.1 µg/g for IOOC standard [27]. Samples which their trees depend on rain water had the lowest cooper concentration, but the samples which their trees irrigated by wastewater had the highest concentration.

Manganese (Mn): Manganese metal is essential for humans at low concentration, but if the intake is at a high concentration, it can cause many problems for the human body. The concentrations of manganese according to their irrigation system were shown in Figure 9.

The minimum and maximum levels of Mn were 0.2644 and 0.7702 µg/g for samples S_2 and S_{1a} which their trees were irrigated pure and natural water respectively. The measured values for samples S_2 in the range of standard value while the concentration of sample S_{1a} are greater than the standard value.

Zinc (Zn): Zinc is one of the main essential trace element in the body which needs at low concentration for growth and considered as cofactor for many enzymes [31,32]. The concentrations of zinc according to their irrigation system were shown in Figure 10.

The zinc content for the measured samples ranged from 7.4032 to 23.7126 µg/g, the sample which their trees irrigated with pure water had the lowest value, while the samples which their trees irrigated by wastewater had the highest value for zinc concentration. The

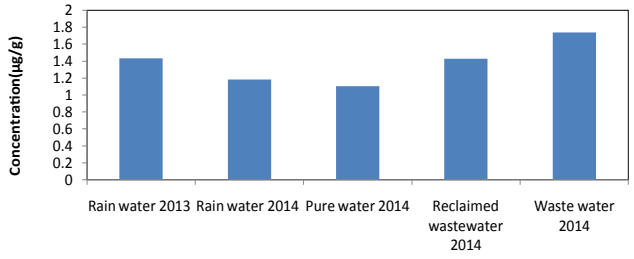

Figure 8: Concentration of Copper in olive oils for all sampling sites of crops of 2013 and 2014.

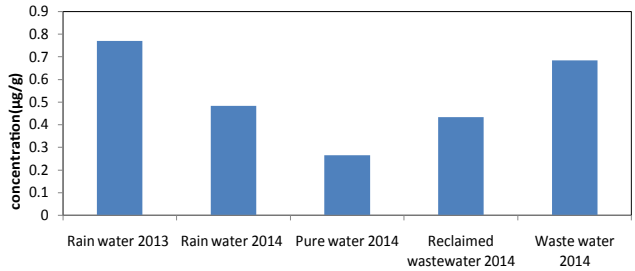

Figure 9: Concentration of Manganese in olive oils for all sampling sites of crops of 2013 and 2014.

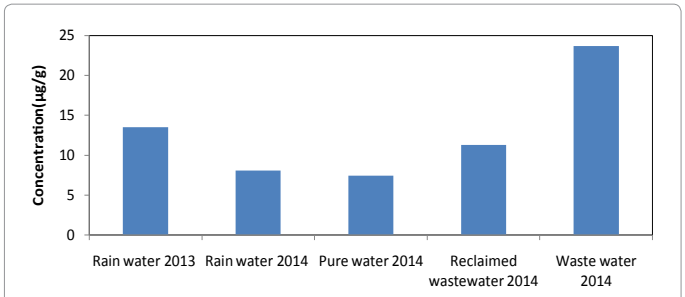

Figure 10: Concentration of Zinc in olive oils for all sampling sites of crops of 2013 and 2014.

concentration of Zn in all measured samples was higher than standard values.

Conclusion

The measured density of olive oil samples of crop 2014 has the highest value was found to be 0.9205 gm/cm^3 for irrigated samples by waste water. The measured results shown that the nature of irrigation is affected on the density results. The experimental results of viscosity of olive oil decreased as a function of temperature. The viscosity of olive oil samples of different location which differ from one location to another according to their irrigation system. We can observe that the results of viscosity values of olive oil of crop 2014 for irrigated sample by waste water are greater than the values of olive oil viscosities for other locations. The viscosity values of olive oil sample which trees irrigated by reclaimed waste water and pure water of crop 2014 are also greater than values of viscosity for samples depend on rain water of crops 2013 and 2014.

The measured acidity results of olive oil increased for samples which trees irrigated by waste water and classified to Lampante oil. The overall results in this study indicate that the acidity in the analyzed olive oil samples also increased for sample irrigated by reclaimed waste water and pure water are greater than samples depends on rain water.

The determination of trace elements in our olive oil samples by using inductive coupled plasma mass spectrometry after microwave assisted digestion represents fast analytical methods to detect the production of oil analysis and safety. The difference in the metals concentration in olive oil samples according to their irrigation system. It's clear that samples were irrigated by waste water contain higher amount of calcium, sodium, potassium, magnesium and zinc are greater than sufficiency range, and the concentration of iron, copper, lead and arsenic for irrigated samples by waste water are greater than concentration of established IOOC.

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