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Effect of Sewage Water Irrigation on Growth Performance and Biomass for Pine Trees, *Pinus brutia* Ten. under Nursery Condition

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Key words:
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ABSTRACT

The effect of different concentrations of sewage water (0, 50 and 100%) on growth performance and biomass of *Pinus brutia* Ten. growing under nursery conditions were examined. Biomass (g/plant)and high of plant (cm) the *Pinus brutia* seedlings treated with sewage water (50%) showed an increase over the control. The sewage water concentration at 50% concentration was suitable for growth of *Pinus brutia* seedlings. The physico-chemical of different concentration water samples showed that Electrical conductivity and total dissolved solid ranged between 425-690 µs/cm and 277-236 mg/L respectively. pH varied between 7.89-8.04. Alkalinity ranged from 204-277 mg $CaCO_3$/L. Total hardness is ranged between 283-288mg $CaCO_3$/L. Calcium and magnesium concentrations varied from 46 to 70 mg/l and 13.12 to 16.76 mg/l respectively. Potassium was ranged between 1.1- 4.9 mg/L and sodium ranged between 7-33 mg/L. Nitrate ranged from 5 to 23 mg/L. The results of heavy metal concentrations were ordered as follow: for %100 sewage water were Fe > Zn > Ni > Mn > Cu > Cd, and for %50 sewage water were Fe > Ni > Zn > Mn > Cu > Cd. While Fe > Mn > Ni > Zn > Cu > Cd for tap water.

تأثير الرى بمياه الصرف الصحي على أداء النمو والكتلة الحيوية لشتلات الصنوبر (*Pinus brutia Ten*)، تحت ظروف المشتل

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الكلمات مفتاحية :
مياه الصرف الصحي، أداء النمو، والكتلة الحيوية.

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الخلاصـــة

تأثير تراكيز مختلفة من مياه الصرف الصحى (0، 50، 100%) على أداء النمو والكتلة الحيوية لشتلات الصنوبر(*Pinus brutia Ten*) والناميه فى ظل ظروف المشتل.أظهرت الكتله الحيوية (غم/نبات) وأرتفاع النبات (سم) والمعامله بمياه الصرف الصحى (50%) زيادة فى النمو على معامله الكونترول. كما أختلفت الصفات الكيمياوية والفيزياوية لعينات المياه حيث تراوحت صفات التوصيليه الكهربائيه والعكورة بين 245–690 مايكروسيمينس/سم و 272–441 ملغم/ لترعلى التوالى. وتفاوتت درجه الحموضيه بين 7,89– 8,04 وتراوحت القلويه 204–277 ملغم/لتر ($CaCO_3$). وتفاوتت تراكيز الكالسيوم والمغنسيوم 46–70 ملغم/لتر و 13,12 – 16,76 ملغم/لتر على التوالى وتراوح البوتاسيوم بين 1,1 – 4,9 ملغم/لتر والصوديوم تراوح بين 7– 23 ملغم/لتر. أما تراكيز العناصر الثقيله للمعاملات فى الدراسه فقد كانت للمعاملة 100% ماء صرف صحى حديد> زنك> نيكل> منغنيز > نحاس > كادميوم، وللمعامله50% ماء صرف صحى حديد> نيكل > زنك>منغنيز > نحاس > كادميوم، فى حين كان حديد> منغنيز > نيكل> زنك> نحاس > كادميوم، فى معامله المقارنه (ماء شرب).

Introduction:

The disposal of sewage and sludge on land cover has been considered as a means of disposal and recycling (Petruzzelli, 1989). In recent years land applications of sewage water has become a common practice in many countries. The reuse of waste water for irrigation in agriculture is one of the oldest forms of water reclamation. It has been suggested and is already practiced in many countries and has been recognized in India and China for centuries (Paliwal, et al., 1998). Awareness of this resource is not apparent in the Middle East and North Africa (Pescod, 1987).. Sewage water, depending on its origin, may be rich in organic matter and nutrient elements as well as toxic heavy metals (Berrow and Webber, 1972). Thus, land disposal of sewage water is highly recommended for fertilization and soil improvement. However, injudicious application to soil may give rise to accumulation of heavy metals in the top soil (Williams et al.,1980). The domestic waste water currently produced is being used for production of agricultural crops, forage grasses and tree seedlings (Karunaicham and Paliwal, 1994). Application of sewage water may improve growth, yield and plant constituents, but can lead to the accumulation of toxic levels of heavy metals in soil and plant tissues (Day et al., 1979). High levels of heavy metals in soil may inhibit crop production, or increase metal uptake without aconcomitant reduction in crop yield (Unger and Fuller, 1985). Thus, it is important that the consequence of agricultural use of these materials be studied. The objective of this study was to evaluate the effect of sewage effluent irrigation on growth performance, in seedlings of *Pinus brutia* Ten. grown under nursery conditions.

Material and Methods:

Pinus brutia Ten seedling was sown in nylon bags containing garden soil. In the nursery, eight months seedlings were grown for 8 weeks. Average temperature for three months was 28 °C while, humidity was 38%.Sewage water was collected from the Erbil sewage channel, *Pinus brutia* Ten seedlings irrigated three times in a week with 150ml of three different concentrations of sewagewater, 0, 50, and 100% (v/v). Seedling growth Plant heights (cm) were measured at the base of seedling until terminal buds. Seedling biomass after eight weeks of growing period, the annual twigs and leaves were collected from the plants and dried at 72 °C in the oven until a constant mass and weight of Leaves, shoots and roots (g) were attained. The water parameters include (EC, pH, TDS, Alkalinity, total hardness, Ca^{+2}, Mg^{+2}, Na^{+1}, K^{+1}, SO_4^{-2}, Cl^{-1}, Fe, Mn, Ni, Cu, Zn, Cd, Reactive Phosphate and Nitrate) EC measured by using EC meter (Hana 6210), TDS calculated mathematically by (EC * 0.64 for waste water and EC*0.55 for Tap water) and pH were measured by using pH meter (Hana 6210). Alkalinity, total hardness, Ca^{+2}, Mg^{+2}, Na^{+1}, K^{+1},SO_4^{-2}, Cl^{-1}, Fe, Mn, Ni, Cu, Zn, Cd, reactive phosphate and Nitrate estimated by (A.P.H.A, 1998). Soil that used in this research for plant growth have a particular property as examined during study, as shown in table (1).

Results and discussions:

1- Irrigated water:

Different concentrations of sewage water used for growth and biomass of *Pinus brutia* Ten., the pH of the %100 sewage water, %50 sewage water and for tap water samples were on alkaline side as shown in table(2). Obtained values of pH are considered as usual condition because, generally, in Iraqi Kurdistan region the pH of water is characterized by a shift towards the alkaline side of neutrality due to the geological composition of its soil components, which composed mainly of $CaCO_3$ and Silicate (Al-Saadi et al., 1993).

Electrical Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentrations, mobility, and on the temperature of measurement (A.P.H.A, 1998). The high level of Electrical conductivity and (TDS) value in the present investigation were recorded in 100% sewage water as shown in table(2) were 690µs/cm and 441mg/L respectively, Increase and decrease of conductivity and TDS of water is related to effect of precipitation, source and geological formation of location (A.P.H.A, 1998).

Total alkalinity of the water is its capacity to neutralize an acid, the amount of strong acid needed to neutralize the alkalinity called total alkalinity (10), The high level of total alkalinity was recorded as shown in table (2) in 100% sewage water was 277 ($mgCaCO_3/L$), The sewage water is alkaline and mostly from domestic sources, which consist of soap water, feces, urine and garbage. The increased level of CO_3 and HCO_3 in the sewage water might be due to flushing of higher amounts of CO_3 and HCO_3 through the sewage water and due to intensive of biological activity producing CO_2 which dissolves in sewage water to form CO_3 and then HCO_3 (Varadarajan, 1992). Hardness of water is the property of water which prevents lathering of the soap (Hynes, 1960). The results of the total hardness through the present study was ranged from (183-288 mg $CaCO_3.l^{-1}$) According to Sawyer and McCarty (1978) all water samples were classified as hard water, because their levels of hardness were between 150 and 300 $mgCaCO_3.l^{-1}$.
Calcium is present in all water samples as Ca^{+2} and is readily dissolved from rocks rich in calcium minerals, particularly as carbonates and sulphates, especially limestone and gypsum. The cation is abundant in surface and groundwater. The salts of calcium and magnesium is common in natural waters as Mg^{+2}, and along with calcium, is a main contributor to water hardness (A.P.H.A, 1998). Magnesium arises as shown in table (1), principally from the weathering of rocks containing ferromagnesian minerals and from some carbonate rocks. Magnesium occurs in many organometallic compounds and in organic matter, since it is an essential element for living organisms. Natural concentrations of magnesium in fresh-waters may range from 1 to 100 $mg.l^{-1}$, depending on the rock types within the catchments (A.P.H.A, 1998). Natural water sources typically containing concentration of up to 10 mg/L Mg^{+2}, such sources rarely contain more than 100 mg/L Mg^{+2} (8). Generally, calcium ion levels dominate over level of magnesium in natural water systems (Hutchinson, 1957). In the present study of the calcium and magnesium concentration as shown in table (2) ranged between (46 – 70 mg **$CaCO_3$**/l) and (13.12 – 16.76 mg **$CaCO_3$**/l) respectively.

Sodium is a highly soluble in water and is leached from the terrestrial environment to the ground water and surface water, most water supplies contain less than 20mg/L of sodium, but in some countries levels can exceed 250 mg/l (W.H.O. 2004). Potassium cation is not present in high concentration in water as a result of mineral dissolution from decomposing plant material and from agricultural runoff (A.P.H.A, 1998), in the present study the high level of sodium and Potassium recorded in 50% of sewage water as shown in table (2). The concentration of Mg, Ca, Na, and K in tap water and in the sewage water are shown intable(1). The concentration of all four elements in the %50 sewage water were higher than that in the100% sewage water and tap water except Ca were the high level recorded in 100% sewage water.Nitrates is generally more stable in ground water than either nitrite or ammonium; this probably due to that nitrate is the final step in oxidation of ammonia and other nitrogen compounds (Bartram and Balance, 1996).The high level of nitrate was recorded in100% sewage water and then tap water the lower level was recorded in 50% sewage water was (23,19,5 mg/l).

Chloride is widely distributed in nature, generally in the form of (NaCl), (KCl) and ($CaCl_2$) salts. Where the high concentration of chloride is recorded in 100% sewage water 28 mg/l as shown in table (2), the high concentration of chloride may due to the highest discharge sewage by man activity that contain human excreta especially urine, laundry detergents and also foods which sodium chloride was add to them(Alam and Akarul, 2006). Sulfate is an abundant ion in the earth crust and its concentration in water may range between few milligrams to several thousand milligrams per liter (Bartram and Balance, 1996). Where the high concentration of Sulfate is recorded in 100% sewage water 53 mg/l as shown in table (2) that may reflect the nature of wastes or through atmospheric decomposition (Tarjan, 2006). Sewage water contain high phosphorus concentration caused by discharge of waste water and the washing out of fertilizer residues used on fields (Rump, 1999), the high level of reactive phosphorus was recorded in 100% sewage water was 100.4 μg $P.PO_4$/l, as shown in table (2), that may reflect as a result of decay organic matter that decomposed biologically to phosphate (Hammer, 1986). The concentration of heavy metals resulting from sewage water were as the following orders; Fe > Zn > Ni > Mn > Cu > Cd for %100 sewage water and Fe > Ni > Zn > Mn > Cu > Cd for %50 sewage water were. While Fe > Mn > Ni > Zn > Cu > Cd for tap water.. High concentration of metals were recorded in 100% sewage water.The concentration of all the metals in the sewage water samples were within the permissible limits and below that which causes toxic effects on plant growth (Varadarajan, 1992).

After 8 weeks of plant irrigation by different concentrations of sewage water, the results showed that, the mean of maximum level increased in plants highest and biomass as shown in figures (1) and table (3) that recorded for (50%/%50) sewage and tap water, for increasing in growth of plants, may be attributed to the absence of toxic effects of sewage water on plants, such as the low levels of heavy metals. Increasing in yield during %50sewage and %50 tap water irrigation that may be due to the increase in organic matter and nutrients especially total and available Nitrogen. These nutrients increased with the increase in the sewage irrigation period which encouraged the vegetation growth (Varadarajan, 1992).The minimum level increased in plants highest and biomass was recorded in irrigated tap water, when metals are in less in soil, they become toxic as they can disturb plant physiology and thus affect plant development beside effects on morphological attributes. Heavy metals can impact on physiological features (Varadarajan, 1992). Paliwal et al. (1998) conducted a study on Hardwickia binate seedlings with 4 different sewages water. They found that the treatments for growth was the 50% concentration, on the other hand, seedling growth performance was delayed with the sewage water concentration at 75 and 100%. This study is in accordance with our study. Furthermore, Cromer (1980) indicated that more care should be given to the possible of forest environments for the restoration of waste water, and it is recommended that forests of Pinus radiata could utilize large quantities of waste water to produce additional timber at the same time as providing considerable repair of drainage waters.This investment indicated that sewage water could be reused after simple treatment for raising seedling quality in conjunction with irrigation water. It is obvious from the study that sewage water nutrients, beneficial for plant growth. Of tree species such as *Pinus brutia* Ten. and may be successfully raised, other species need to be tested and introduced. In this way sewage water, which may be relatively high in nutrients, can be reused.

Table 1: Some physical and chemical properties of the used soil in Erbil City.

Properties	**Experiment media**
pH	**7.4**
Electrical conductivity (EC)	**0.4 ds-m $^{-1}$**
Total Nitrogen	**0.20%**
P_2O_5	**6.3 ppm**
K_2O	**120 ppm**
Organic matter	**0.2 %**
Clay %	**20**
Silt %	**12.5**
Sand %	**67.5**
Soil Texture (Hygrometer Method)	**sandy loam to sandy clay loam**

Table 2: The concentration of the physical and chemical parameters of irrigated water samples.

Parameters	Sewage water100%	Sewage water 50%	Tap water
pH	7.89	7.98	8.04
EC(µs/cm)	690	545	425
TDS(mg/l)	441	348	272
Total alkalinity(mg$CaCO_3$/l)	277	236	204
Total hardness(mg$CaCO_3$/l)	288	205	183
Ca(mg/l)	70	57	46
Mg(mg/l)	13.12	16.76	15.3
Cl(mg/l)	28	16	15
SO4(mg/l)	53	23	28
Na(mg/l)	7	33	18
K(mg/l)	1.1	4.9	2.8
NO_3(mg/l)	23	5	19
PO_4 (µg P.PO_4/L)	100.4	41.8	0.59
Fe(µg/l)	196.6	71.3	19.6
Zn(µg/l)	129	31.88	0.86
Cu(µg/l)	21.5	4.11	0.8
Cd(µg/l)	3.4	0.43	0.09
Mn(µg/l)	88	15.36	7.9
Ni(µg/l)	119.7	45.7	3.5

Table (3): Seedling height (cm) during the study period.

	block	plant	initial height	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8	Total increased high of plant after 8 week
50% sewage water	1	1	41.1	41.2	41.2	41.3	41.4	41.5	41.5	41.6	41.7	
	1	2	27.3	27.3	27.3	27.4	27.4	27.5	27.5	27.6	27.6	
	1	3	51.3	51.3	51.3	51.3	51.4	51.4	51.4	51.4	51.5	
		Average	39.9	39.93333	39.93333	40	40.06667	40.13333	40.13333	40.2	40.26667	0.36
	1	1	29.9	30	30.1	30.1	30.1	30.2	30.2	30.2	30.3	
	1	2	31.3	31.3	31.4	31.4	31.4	31.5	31.5	31.5	31.6	
	1	3	39	39.1	39.1	39.1	39.2	39.2	39.4	39.4	39.5	
		Average	33.4	33.46667	33.53333	33.53333	33.56667	33.63333	33.7	33.7	33.8	0.4
	1	1	41.5	41.6	41.6	41.6	41.7	41.7	41.7	41.8	41.8	
	1	2	30.4	30.5	30.6	30.6	30.7	30.7	30.7	30.8	30.8	
	1	3	25.9	26	26.1	26.1	26.2	26.2	26.3	26.3	26.4	
		Average	32.6	32.7	32.76667	32.76667	32.86667	32.86667	32.9	32.96667	33	0.4
		mean of total increased high of plant after 8 week										0.38
Tap water	2	1	33.2	33.2	33.2	33.3	33.3	33.3	33.4	33.4	33.4	
	2	2	29.1	29.1	29.2	29.2	29.3	29.3	29.4	29.4	29.5	
	2	3	32	32	32.1	32.2	32.3	32.3	32.3	32.3	32.4	
		Average	31.43333333	31.43333	31.5	31.56667	31.63333	31.63333	31.7	31.7	31.76667	0.33
	2	1	37	37	37.1	37.1	37.1	37.1	37.1	37.2	37.2	
	2	2	27	27	27.1	27.1	27.1	27.2	27.2	27.2	27.3	
	2	3	29.9	29.9	30	30	30	30	30.1	30.1	30.1	
		Average	31.3	31.3	31.4	31.4	31.4	31.43333	31.46667	31.5	31.53333	0.23
	2	1	40.2	40.3	40.3	40.4	40.4	40.4	40.4	40.5	40.5	
	2	2	29.4	29.5	29.5	29.6	29.6	29.6	29.6	29.7	29.7	
	2	3	26.4	26.4	26.4	26.4	26.5	26.5	26.5	26.5	26.6	
		Average	32	32.06667	32.06667	32.13333	32.16667	32.16667	32.16667	32.23333	32.26667	0.26
		mean of total increased high of plant after 8 week										0.27
100% sewage water	3	1	30.7	30.7	30.7	30.8	30.8	30.9	30.9	30.9	30.9	
	3	2	36.3	36.3	36.4	36.5	36.6	36.6	36.7	36.7	36.7	
	3	3	38.1	38.1	38.2	38.2	38.3	38.3	38.4	38.4	38.4	
		Average	35.03333333	35.03333	35.1	35.16667	35.23333	35.26667	35.33333	35.33333	35.33333	0.3
	3	1	28.2	28.3	28.3	28.4	28.4	28.5	28.5	28.5	28.5	
	3	2	32.6	32.7	32.7	32.8	32.8	32.8	32.8	32.9	32.9	
	3	3	32.4	32.4	32.5	32.5	32.6	32.6	32.7	32.7	32.7	
		Average	31.06666667	31.13333	31.16667	31.23333	31.26667	31.3	31.33333	31.36667	31.36667	0.3
	3	1	30.7	30.8	30.8	30.9	30.9	31	31.1	31.1	31.1	
	3	2	30.6	30.6	30.6	30.7	30.7	30.7	30.7	30.8	30.8	
	3	3	25.8	25.8	25.8	25.9	25.9	25.9	26	26	26	
		Average	29.03333333	29.06667	29.06667	29.16667	29.16667	29.2	29.26667	29.3	29.3	0.27
		mean of total increased high of plant after 8 week										0.29

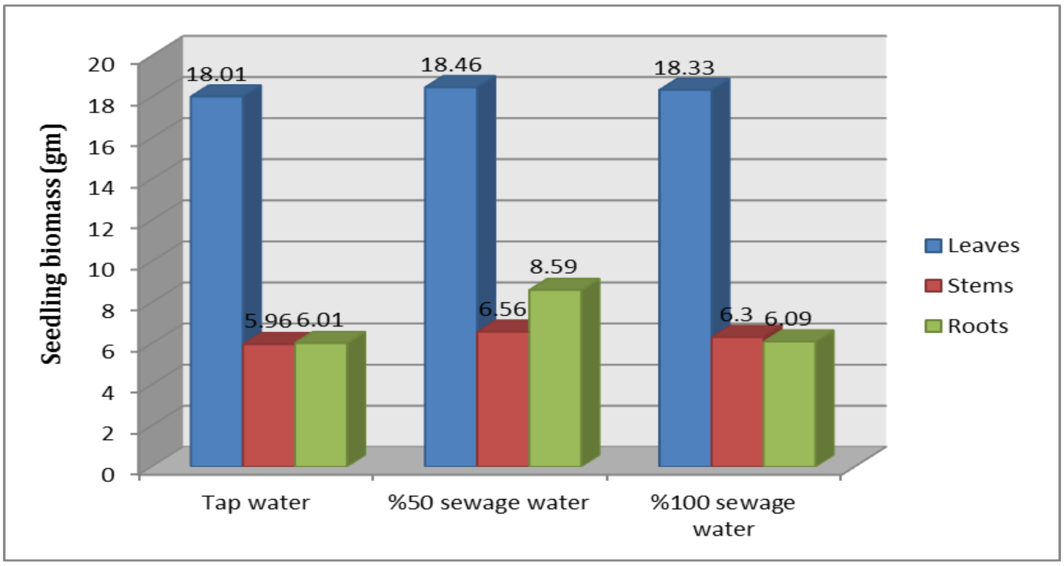

Figure 1: Seedling biomass (gm) with different watering treatments.

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