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Some Soil Properties of Lime Stabilized Urban Wastewater and Effects on Barley's Yield and Mineral Matter Content

[1]Betül Bürün, [1]A. Levent Tuna, [2]İbrahim Yokaş and [3]Hatice Ege
[1]Department of Biology, Faculty of Science, Mugla University, Mugla, Turkey
[2]Ortaca Polytechnic, Mugla University, Mugla, Turkey
[3]Alasehir Polytechnic, Celal Bayar University, Manisa, Turkey

Abstract: Applying lime-stabilized urban wastewater on barley (*Hordeum vulgare* L.cv. Kaya) has been studied with the two year experiments. The effects of 3-25 ton da^{-1} wastewater applications were also investigated in these experiments. In addition to these, the effects of different wastewater applications in four doses ranging from 6 to 24 were determined on with the treatment of 20 kg da^{-1} 15:15:15 NPK composed fertilizer. Significantly increases on the P (mg kg^{-1}) and K (mg kg^{-1}) contents of soils and N (g kg^{-1}), P (g kg^{-1}), K (g kg^{-1}), Ca (g kg^{-1}), Fe (mg kg^{-1}), Mn (mg kg^{-1}), Cu (mg kg^{-1}) and Zn (mg kg^{-1}) contents of leaves were observed. Increasing the doses of wastewater applications effected yield components positively. As a result of high dose application, a significant yield increase was also observed. When the wastewater was applied to soil, grain yield and nutrient content of barley increased considerably. There was no negative effect on protein content either. As a conclusion, stabilized wastewater can be used under controlled conditions in agricultural areas.

Key words: Lime, stabilized, wastewater, barley, yield, mineral content

INTRODUCTION

As a result of urbanization, urban wastewater has increased fast, so reusing urban wastewater has become a research topic for a long time. Also, the pollutant components should be removed.

Septic wastes are liquids and solids that are taken out of septic tanks, cesspools or mobile toilets. It contains 96-99% water, heavy metals at an acceptable ratio and some nutrient elements like nitrogen, phosphorus, potassium and calcium. Septic waste is an important soil conditioner by the reason of organic matter that it contains. Furthermore, macro and micro nutrient elements in it have agricultural productivity-improving properties. In the agricultural areas irrigated with the septic wastewater, the nutrients that septic waste includes are seriously taken into consideration in fertilizing programs (Anonymous, 1994).

Wastewater treatment with a chemical substance is an effective stabilization method. On this account, the first idea that comes to mind is lime which is easy to get and apply. The lime, which is a significant stabilization substance, has been used in the urban waste treatment facilities in USA since the beginning of 90s (Hing *et al*., 1992). In a standard lime stabilization, $Ca(OH)_2$ or CaO is added to wastewater until pH reaches at 12. The main goal is here to keep pH at 12 for 30-60 min with the addition of lime (EPA, 1994). This process exterminating of pathogens and the other micro organisms in septic wastes results in reducing the biological activities, slowing the decomposition of organic matters down and finally eradicating the odour problem.

When the wastewater, which generally includes 5-7% dry matter and 90-95% water, is applied to the agricultural lands, it affects physical and chemical properties of the soil favorably. Septic wastes regulate the air circulation and capacity of holding water by increasing the porosity amount in the soils treated. It results in improving plant root system positively and finally affecting the soil fertility by reusing of nutrient elements in the septic. One of the most important methods for the storage of septic waste is the land applications. Thus, both the polluted water and the nutrient elements in the water can be applied to the soil and plants by recycling. Septic wastes are reused by applying to the agricultural areas, recreation sites and forests mostly (EPA, 1983).

There have been significant findings, proving that septic wastes increased the crop yields when applied to the agricultural areas. According to a study carried out by Dowdy *et al.* (1978) greater amount of yield can be obtained with the controlled waste applications, compared to the usual fertilizer application. Jimenez *et al.* (1995) has

Corresponding Author: Dr. A. Levent Tuna, Department of Biology, Faculty of Science, Mugla University, Mugla, Turkey
Tel: +90 252 2111520 Fax: +90 252 2238656

reported that the wastewater, which didn't include toxic heavy metals, increased the yield of maize and clover by regulating the soil fertility. They have suggested $FeCl_2$ (50 mg L^{-1}) and Ca $(OH)_2$ (250 mg L^{-1}) in order to exterminate pathogenic organisms and heavy metals in wastewater as well.

Reusing urban wastewater without causing any problem on public health is a highly important matter. Reusing septic wastes for agricultural purposes is on the agenda in Britain (http://www.defra.gov.uk/environment/water/quality/uwwtd/report02/07.htm).

Depending on the urbanization, discharge of wastewater has highly increased. In this study, we have aimed to reuse urban wastewater that is rich in nutrient but includes no heavy metal for agricultural production. In this way, it will be able to protective for the environmental health and beneficial economically. Firstly, it was dwelled upon whether stabilized urban wastewater used in this experimental study affects the soil negatively or not. Considering that the soil is an insufficient and important resource, reusing wastewater should be a priority to research on. Moreover, we aimed to reduce fertilizer applications by taking the fertilization programmers into consideration.

MATERIALS AND METHODS

Trial site characteristics: Field experiments were conducted in the city center of Mugla during the seasons 2000-2001 and 2001-2002. Province of Mugla is in the south-west Aegean Region in Turkey and it shows typical Mediterranean climate. In the mentioned region; Red Brown Mediterranean soils (Alfisols), which have A, B, C horizons, mostly exist.

In the region, the average temperature is 15.3°C and average rain in a year changes between 600-750 mm (Anonymous, 1998).

Properties of the wastewater and its general application: The liquid wastes were drawn off the cesspools of the houses in the city center of Mugla and searched whether reusing them was possible for the agricultural production after being amended with $Ca(OH)_2$ in the stabilization unit.

Four kilogram lime Ca $(OH)_2$ per 1000 L of septic wastes was applied, in the urban wastes stabilization facilities. In this way, the pH was kept at 12 for 30 min and immediately it was poured into the storage basins. After solid wastes precipitated to the basin bottom, the liquid wastes are drawn off and then, taken to the application site. The urban waste, used as experimental material, was analyzed periodically in both experiment years and it was determined that it included elements of Fe, Mn and Cu at a trace level and was rich in N, P, K, Ca but it didn't include any toxic heavy metals. It was also measured that EC was 1.7 dS m^{-1} and pH was 11.2. The stabilized urban wastewater was analyzed and data's shown Table 1.

Table 1: Chemical properties and elemental composition of the urban wastewater

Constituent	Average amount (meq L^{-1})	Constituent	Average amount (mg L^{-1})	Constituent	Average amount (mg L^{-1})
Na^+	4.98	Total Na	91.00	Total B	0.42
K^+	0.74	Total P	1.22	NH_4^+-N	35.7
Ca^{2+}+Mg^{2+}	4.60	Total K	27.00	NO_3^--N	2.45
Total cations	10.32	Total Ca	300.00	NO_2^--N	19.95
Cl^-	2.80	Total Mg	10.20	COD[a]	93.00
SO_4^{2-}	0.62	Total Fe	0.22	BOD_5[b]	13.00
CO_3^{2-}	2.80	Total Cu	0.72	TSS[c]	12.00
HCO_3^-	4.20	Total Mn	0.90	SAR[d]	3.28
Total anions	10.42	Total Zn	0.80	IWC[e]	C_3S_1

[a]: COD: Chemical Oxygen Demand, [b]: BOD_5: Biochemical Oxygen Demand, [c]: TSS: Total Suspended Solids, [d]: SAR: Sodium Adsorption Ratio, [e]: IWC: Irrigation Water Class

Water samples were analyzed for total solids, EC, Na, K, Ca, Mg, CO_3, HCO_3, Cl, SAR, IWC and B (US Salinity Lab. Staff, 1954), pH (Jackson, 1967), SO_4 and P (Merck, 1973), NH_4-N, NO_3-N and NO_2-N (Balks and Reekers, 1955), Fe, Cu, Mn and Zn (Slavin, 1968), BOD_5 and COD (Egemen and Sunlu, 1999)

Experimental layout and treatments: As a plant material, a species of barley (*Hordeum vulgare* L. cv. Kaya) was grown and experiments were conducted on different field in the same region between the years of 2000-2002.

The experiments were established in a Randomized Block Design with three replications. In the 2000-2001 experiment, plot largeness was 9 m^2 and seeds were sowed in rows. 30 kg da^{-1} of 15:15:15 NPK composed fertilizer was applied to the all plots as a basal dressing. Stabilized urban waste was applied in different four doses as 3, 6, 9 and 12 ton da^{-1}. In the control plots, 40 kg da^{-1} 15:15:15 of composed fertilizer was given. The first waste application was carried to the same time with planting. Later, total seven applications were done at the intervals of 20-25 days.

In the 2001-2002 experiment, the same species was sowed in a row as like in the past season but largeness of each plot was 15 m^2. Waste amount was also doubled as 6, 12, 18 and 24 ton da^{-1}. No basal dressing was applied to the plots. Furthermore, the waste with chemical fertilizer was experimented and 20 kg da^{-1} 15:15:15 (plus) was applied to the all waste doses as an addition. As in the first year, the fertilizer (15:15:15) was applied to the control plots at a ratio of 40 kg da^{-1}.

The first waste application started with the sowing and total 6 applications was done at the intervals of 20-25 days until the end of harvest. Along this year, the same application in the first year was repeated in the same way. Some soil properties (0-30 cm) belonged to the experimental sites of both years was shown in Table 2.

Table 2: Selected chemical and physical properties of the soil at the experimental site (0-30 cm depth)

	Average amount	
Constituent	2000-2001	2001-2002
$CaCO_3$ (g kg^{-1})	188.00	182.00
pH	8.11	7.89
EC (dS m^{-1})	0.47	0.65
Organic matter (g kg^{-1})	17.30	10.80
Total nitrogen (g kg^{-1})	0.91	0.96
Potassium (mg kg^{-1})	93.30	115.00
Phosphorus (mg kg^{-1})	12.33	11.40
Sand (g kg^{-1})	224.00	244.00
Silt (g kg^{-1})	440.00	420.00
Clay (g kg^{-1})	336.00	336.00
Texture	Silty-loam	Silty-loam

Table 3: The soil pH and P (mg kg^{-1}), K (mg kg^{-1}) contents following the first and last applications in both seasons

	First period			Last period		
Treatments	pH	P	K	pH	P	K
2000-2001 season						
Control	7.55c	32.2a	137a	7.77c	23.4a	369b
3 ton da^{-1}	7.87b	11.9b	90e	7.91a	11.5c	243e
6 ton da^{-1}	7.92a	12.7b	107c	7.80b	10.3d	279d
9 ton da^{-1}	7.95a	11.3b	101d	7.77c	23.1a	288c
12 ton da^{-1}	7.81b	11.0b	125b	7.73d	12.7b	416a
2001-2002 season						
Control	7.90	14.1b	151a	7.91	15.1c	150a
6 ton da^{-1}	7.88	10.9e	140c	7.97	18.6a	155a
12 ton da^{-1}	7.84	13.5c	139c	7.84	16.8b	154a
18 ton da^{-1}	7.91	14.7a	144b	7.89	13.9d	154a
24 ton da^{-1}	7.87	13.1d	140c	7.86	18.1a	133b
	ns			ns		
Control	7.90	14.1a	151a	7.91	15.1d	150d
6+plus	7.79	11.2d	133c	7.89	18.7b	145c
12+plus	7.82	13.3b	136c	7.89	17.9c	157b
18+plus	7.89	12.6c	145b	7.92	18.5b	160a
24+plus	7.92	14.4a	155a	7.93	19.8a	145c
	ns			ns		

Data's are means of three replications, Means followed by the same letter in each column are not significantly different p<0.01, ns: not significant

Soil and plant sampling and analytical determinations: During the vegetation period, periodic physical observations were made and collected soil and plant samples in order to evaluate the state of nutrition. Soil sample were collected separately from the depth of 0-30 cm in every plot before the waste application. In both years' soil samples; it was determined that $CaCO_3$, volumetrically, EC, by 1:5 w/v soil/distilled water method, organic matter, titrimetrically, soil texture, by hydrometer method, available K, according to 1 N ammonium acetate method and available P, by a vanadate-molybdate method.

The leaf samples of the barley were obtained during the period that nutrient elements were stable. The samples were dried and ground at 70°C for 24 h. Wet digestion with ¼ HNO_3: $HClO_4$ mixture was treated to the samples. These samples were poured into a 100 mL volumetric flask and made up to 100 mL with distilled water.

In these samples, N was determined by Kjeldahl method Bremner and Mulvaney (1982) and available phosphorus was determined vanadate-molybdate method as spectrophotometrically, potassium, calcium, sodium flame emission photometrically, magnesium, iron, copper, manganese and zinc were all determined as atomic absorption spectrophotometrically (Chapman and Pratt, 1982).

Statistical analysis: Data were analyzed for significance using the General Linear Model (GLM) procedure in the SAS statically program (SAS, 1996). Means were separated by LSD p<0.01 when f-tests were significant at p<0.01.

RESULTS AND DISCUSSION

Soil response to wastewater treatments: The soil samples were regularly collected from the experimental sites established in both years and analyzed before each waste application in order to determine the effects of stabilized urban wastewater on soil. According to the results, it was observed that there was no change at the soil pH and $CaCO_3$, EC ratios. It was also seen that organic matter content increased slightly but P and K contents significantly (Table 3).

Taking the data obtained in both seasons into consideration, the soil pH which is an important factor for the soil fertility didn't change significantly after the waste applications in increasing doses. Although, pH was higher in the wastewater-applied plots than it was in control group, the increase ratio wasn't at a level that may affect the soil fertility negatively. When the highest wastewater dose application was taken into consideration; the soil pH that was 8.11 before the experiment in the first year decreased to 7.73 by leading a fluctuating movement (Table 3). As for the second year, the soil pH that was 7.89 before the experiment decreased to 7.86 at the 24 da^{-1} application, but it increased to 7.93 at the 24+plus dose (Table 3). It was buffer capacity of the soil and diluting effect of rain during the vegetation period probably prevented a severe increase of the soil pH although applied waste's pH was so high. As it's well known, clay minerals that are one of the important components of the soil, form soil's colloidal structure and affect the soil buffer capacity significantly (Marschner, 1995). That soil of the experiment has a high clay ratio explains this situation. The obtained data shows that there has been no negative effect on the soil pH with wastewater applications in increasing doses.

The phosphorus which is an important nutrient had an increasing ratio in the soil with the applications in increasing doses. In 2000-2001 seasons, the soil P which was 12.33 mg kg da^{-1} before the experiment went up and down with the applications but it had an increasing movement in the last period. The highest increase was in the control group which chemical fertilizer was applied. The increase in the group which 9 ton da^{-1} wastewater was applied, reached at 23 mg kg^{-1} in the last period, it was the top level for P and the increase was nearly 85%, compared to the before the experiment (Table 3).

The potassium content, which is another important nutrient, also increased with the wastewater applications in increasing doses. The soil K content, that was 93.3 mg kg^{-1} before the experiment, increased continuously as from the first application. We reached at the maximum K content just before the last wastewater application. The highest K content was 416 mg kg^{-1} in the group, which 12 ton da^{-1} wastewater was applied (Table 3). Here, the increase was nearly 350%, compared to the before the experiment. Differences between potassium increase ratios may be because of changing potassium ratios in the wastewater applied in each term.

In the second year of the experiment, it was observed a similar movement in the soil pH and P, K contents with the first year and didn't observe any unfavorable change in the soil pH depending on the waste applications. In each period, soil P and K contents increased moderately but this increase was more evident in waste applications with chemical fertilizers. It is conducted two applications in two groups in order to measure the increase ratio of the soil P and K contents. In the first group to which 24 ton da^{-1} waste treated, measured the soil P content was measured at the ratio of 13.1 mg kg^{-1} after the first application, but this ratio rose to 18.1 mg kg^{-1} following the last application. In this group, increase ratio of P content was nearly 40%. In the second group to which 24 ton da^{-1} ton waste and chemical fertilizer treated, soil P content level was measured at the ratio of 14.4 mg kg^{-1} after the first application but it rose to 19.8 mg kg^{-1} following the last application. In the second group; Increase ratio of P content was observed approximately 35% (Table 3). We observed fluctuated movements in the soil K content level with the waste applications, but the movement was more aggressive in waste plus chemical fertilizer applications.

For septic wastes contain plant nutrients and have conditioning effect on soil fertility, they increase soils nutrient content. Saviozzi *et al.* (1991) determined the effects of wastewater on agricultural lands in a study that barley was used as a test plant According to the obtained results from this study, available phosphorus and exchangeable potassium contents increased and seed germination was affected positively from the waste water.

Akrivos *et al.* (2000) investigated the agricultural applications of waste water stabilized with lime. In this study CaO was used as a stabilizer and pH ratio of the waste was increased from 7.6 to 12.3. Following the stabilization, the ratio of Hg, Pb, Ni, Zn, Cr, Cd and Cu elements in the waste decreased considerably as result of the fixation property of lime, treated as a stabilizer. In the experiments, cotton was used as a test plant and 0, 10, 20, 30 ton ha^{-1} waste doses were treated. After the experiment, no change was observed at the soil pH and EC ratio but slight increase was seen in the organic matter content. Significant increases were observed in the dry matter ratio of cotton and its seed yield when compared to chemical fertilization and the control group.

Ibrahim *et al.* (1995) used urban waste water in order to grow various vegetables. In their study, they used spinach, radish, carrot and cauliflower as test plants and they searched the effect of waste water on the crop yield and the NO_3 nitrogen of those plants. According to the obtained results from the study, in which river water was used as control, use of waste water resulted in considerable amount of increase in crop yield and in NO_3 content of the plants but no change was observed in the Pb and Cd contents.

Yield and yield components: The use of waste water for agricultural purposes provides favorable changes in the mineral matter contents of plant and soil a considerable increase in yield statistically as well. This study, mainly dealt with the waste applications, yield of barley which was used as a test plant and its yield components.

Plant grew in height both in the first and the second year experiments with waste applications but remained under the control group. However in the unfertilized experiment season of 2001-2002, plant height was in the same group with the control at the last application dose. The striking thing is that plant grew in length regularly with the waste water in increasing doses in both the first and the second year experiments. With the anatomical observations. It was found out that internodium height of the plant grew internodium diameter widened. Stalk not only grew in length but also thickened and finally saw thickening in membrane (Ege *et al.*, 2004). Results showed positive indication for the strength of the plant stalk. When the waste application level was increased, the spike grew in length and the number of grains in the spike increased. Spike length was affected more positively when compared to the control group, especially at high dose treatments. Obtained the best spike length in the experiment season of 2000-2001 at 12 ton da^{-1} waste dose and in 2001-2002 at 24 ton da^{-1} and 18+plus waste dose. Thousand grain weights, which are assumed to be

Table 4: Barley yield parameters and grain yield

Treatments	Plant length (cm)	Spike length (cm)	Harvest index (%)	No. of spikes m^{-2}	No. of grain spike $^{-1}$	Hectoliter weight (kg)	Weight 1000-grains (g)	Yield (kg da^{-1})
2000-2001 season								
Control	87.3a	7.57b	33.0	430.0a	19.0	63.40a	43.57a	319a
3 ton da^{-1}	46.9d	5.30d	23.6	193.3d	15.3	56.40c	35.60b	86d
6 ton da^{-1}	51.8d	5.54d	30.3	238.3c	17.0	57.53c	37.33b	110d
9 ton da^{-1}	61.1c	6.03c	29.6	278.3b	16.6	59.76b	40.77a	144c
12 ton da^{-1}	70.7b	8.03a	30.3	478.3a	17.3	64.90a	41.70a	207b
			ns		ns			
2001-2002 season								
Control	73.8a	6.87c	36.3c	227.0b	18.4ab	61.2	49.27	206b
6 ton da^{-1}	46.3c	5.71d	36.0c	137.8d	16.1b	59.8	46.87	103d
12 ton da^{-1}	57.1b	7.33b	46.0b	155.4c	20.5a	60.4	49.60	158c
18 ton da^{-1}	53.2c	6.67c	57.0a	254.8a	15.9b	57.1	49.70	201b
24 ton da^{-1}	71.6a	8.25a	54.6a	232.3b	21.5a	57.8	46.77	233a
						ns	ns	
Control	73.8	6.87c	36.3c	227.0b	18.4	61.2	49.27	206c
6+plus	60.6	6.35c	38.3b	188.5c	17.5	61.6	49.25	162e
12+plus	65.4	6.82c	47.0a	214.4b	18.4	61.9	50.25	198d
18+plus	71.4	8.16a	47.6a	232.6b	20.1	58.5	48.25	225b
24+plus	69.3	7.21b	48.0a	265.5a	19.4	62.4	50.17	258a
	ns				ns	ns	ns	

Data's are means of three replications, Means followed by the same letter(s) in each column are not significantly different $p<0.01$, ns: not significant

a significant yield component, weren't affected unfavorably with the increase of waste application levels. Thousand grain weight of the variety is accepted as 35-49 g by Kün (1998) but in this study thousand grain weight changed between the ratios of 35.60-50.25 and the highest thousand grain weight ratio at 12+plus dose was observed which was 50.25 g. Moreover, the increase of hectoliter weight ran parallel with the increase of waste dose and the grains got plump and grew large. The most prominent increase in hectoliter weight was obtained in the experiment season of 2000-2001 at 12 ton da^{-1} waste dose and weight increase in that dose surpassed the control group (Table 4). No significant change was seen in harvest index in the experiment season of 2000-2001 but in 2001-2002 harvest indexes surpassed the control group with the increase of waste doses. In the fertilized and unfertilized experiment season of 2001-2002 the rate of increase in harvest index is quite prominent at 18 ton da^{-1} and 24+plus waste treatment doses respectively. The number of spike (per squarmeter) is another yield component, which was affected favorably from the increase in waste dose. In both season experiments, as we increased the waste dose, it was seen that parallel increase in the number of the spikes and that increase was observed more prominently particularly at high doses.

As it can be seen from the Table 4, in the experiment season of 2000-2001 the yield obtained in the control group, to which chemical fertilizer including NPK treated, was 319 kg da^{-1} and along with the increase of waste doses, a parallel increase was seen in the yield as well. The yield in the group to which 12 ton da^{-1} waste treated was, approximately 125% more than the group to which 3 ton da^{-1} waste treated. That significant increase in the yield can be evaluated as a finding proving nutritious effect of the waste water. Similar results was obtained in the second year of the experiment but when compared to the first year the amount of yield was lower and that decrease in the yield caused by the negative weather conditions seen in the second year of the experiment. In the second year, waste doses doubled and in addition to waste, 20 kg da^{-1} 15:15:15 NPK composed fertilizer (plus) was added and by this way we aimed to determine the additional increase in the yield which would be created by fertilizer treated with the waste. In the first group we treated waste only in increasing ratios and the amount of yield that we obtained in the 18 ton da^{-1} waste dose was approximately equal to the amount of yield obtained in the control group. As for the group in which the waste treated with fertilizer, the amount of yield was only higher than the waste treated group as it was considered. This additional increase in yield, which was resulted from the additional fertilizer, neared to control group at 12+plus dose and it surpassed the control group at 18+plus dose. When the increases in yield at the highest doses were considered by comparing the control group, the increase ratio was observed by 13% in the waste group and 25% in the plus group.

When compared the relationship between the yield and the yield components generally, it was seen the positive effect of waste water on this relationship and this positive effect was directly related to the nutrients which waste water contains. But a negative thing is that a nutrient of the waste water, used in each period, was different from each other. For that reason homogeneous

Table 5: Leaf elemental analyze results according to waste application levels in barley in the experiment season of 2000-2001

	Macro elements (g kg^{-1} DW)					
Treatments	N	P	K	Ca	Na	Mg
Control	10.2	0.7c	4.4b	8.2	0.53	0.7
3 ton da^{-1}	11.2	1.1b	4.6b	8.2	0.56	0.6
6 ton da^{-1}	9.8	0.8c	3.7b	8.4	0.61	0.9
9 ton da^{-1}	10.6	1.4a	6.6a	8.0	0.60	1.1
12 ton da^{-1}	11.2	0.9c	4.7b	9.4	0.56	1.3
	ns			ns	ns	ns

	Micro elements (mg kg^{-1} DW)			
Treatments	Fe	Cu	Mn	Zn
Control	127.6c	2.46	14.6c	4.68c
3 ton da^{-1}	151.8b	2.46	17.3b	3.66d
6 ton da^{-1}	163.5b	1.73	20.9a	5.64b
9 ton da^{-1}	190.6a	1.41	20.6a	7.61a
12 ton da^{-1}	170.2b	2.46	23.9a	7.33a
		ns		

Data's are means of three replications, Means followed by the same letter in each column are not significantly different $p<0.01$, ns: not significant

Table 6: Leaf elemental analysis results according to waste application levels in barley in experiment season of 2001-2002

	Macro elements (g kg^{-1} DW)				
Treatments	N	P	K	Ca	Mg
Control	3.5b	0.50c	5.5b	5.6b	0.4
6 ton da^{-1}	2.8c	0.63b	4.5c	8.5a	0.5
12 ton da^{-1}	4.2b	0.60b	6.0a	8.2a	0.4
18 ton da^{-1}	4.9a	0.71a	6.8a	8.1a	0.4
24 ton da^{-1}	4.9a	0.67a	6.4a	8.5a	0.5
					ns
Control	3.5c	0.50b	5.5c	5.6c	0.4
6+plus	1.4d	0.40b	7.1b	8.7a	0.4
12+plus	4.7b	0.49b	8.0a	8.2b	0.4
18+plus	4.8b	0.46b	7.5b	9.1a	0.4
24+plus	7.7a	0.82a	8.1a	8.8a	0.5
					ns

	Micro elements (mg kg^{-1} DW)			
Treatments	Fe	Cu	Zn	Mn
Control	79.2c	1.8c	1.1c	8.7b
6 ton da^{-1}	67.1b	7.1b	0.9c	7.1c
12 ton da^{-1}	82.4b	8.7a	1.4c	9.2b
18 ton da^{-1}	82.8b	9.0a	2.1b	14.9a
24 ton da^{-1}	86.5a	9.3a	9.5a	10.1b
Control	79.2b	1.8d	0.9c	8.7c
6+plus	64.2c	2.1d	0.6c	10.0b
12+plus	68.5c	7.1c	1.3c	8.2c
18+plus	89.8a	12.9a	2.8b	17.2a
24+plus	80.9b	11.0b	6.0a	11.1b

Data's are means of three replications, Means followed by the same letter in each column are not significantly different $p<0.01$, ns: not significant

fertilization can't be applied and in each period differences can be seen on plant growth in terms of nutrition. The way to eradicate that problem is to analyses the wastewater, if needed, to supplement with mineral and to provide the homogeneity. In this study, we experienced such negativity. Nevertheless, it was proved that waste water had nutritive and improving properties for the plants and soil as we mainly aimed.

Vavich (1962) studied the effects of urban waste water on the yield of wheat, barley and oat and the grain quality of those plants. In the study, normal irrigation water was used as a control and grain yield and percent total protein contents of the those grains increased significantly. The same researchers in another study found out that the malt quality of barley, which was planted for beer and irrigated with the waste water and the ratio of alpha amylase and nitrogen were affected positively.

Mineral nutrition and protein content of barley: One of the most important factors that make the use of waste water in agricultural lands charming is the plant nutrients that they contain. Waste water, which doesn't include heavy metals or include them in the reference limitations, increase fertility of the soil that they treated thanks to the nutrients contents that they include. But when lime is used as a stabilization matter as in present study, primarily P, which is in waste water and some available micro nutrients are liable to expose to fixation. However waste water becomes beneficial again after treated to the soil and can be absorbed by the plant.

In the results of Table 5 waste applications increased the nutrient levels of leaves as much as control group at least. Although that increase in the nutrient levels of leaves is seen in all elements, it is clearer in Fe, Mn and Zn elements and this shows that the urban waste water used in agricultural irrigation is rich in above mentioned micro elements. In many studies it was reported that the urban waste water, not including heavy metal, increased the mineral matter content of soil and plant that it was treated.

Eid and Shereif (1996) researched the effects of the waste water on the mineral matter contents of barley and faba bean that are grown in greenhouse conditions. According to experiment results, P, N, Mn and Ni content of the plants increased at a significant rate and that increase was by 18% for Mn and 9% for Ni.

Tuna *et al.* (2001) determined the waste water application to grass and verbana at five doses and following the application no significant change was seen at the % salt content of the soil, but an increase was seen in pH when compared to control group. In the grass experiment, as the waste water dose increased plant height and fresh weight increased but dry matter decreased and with the waste applications vegetative growth was stimulated. Moreover N, P, K and Na% increased in terms of plant nutrient content, the increase in Ca% was evaluated non-significant statistically. In the pot experiment carried out with the verbena, soil salt content didn't change but pH increased. Plant height and number of leaf pair showed a considerable increase statistically.

Table 7: Protein ratios obtained after the first and the second year experiments according to waste water applications

Treatments	Protein (%)
2000-2001 season	
Control	9.45a
3 ton da^{-1}	9.43a
6 ton da^{-1}	9.10b
9 ton da^{-1}	9.12b
12 ton da^{-1}	9.47a
2001-2002 season	
Control	9.12c
6 ton da^{-1}	10.32a
12 ton da^{-1}	9.92b
18 ton da^{-1}	9.83b
24 ton da^{-1}	9.60b
Control	9.12b
6+plus	8.97c
12+plus	8.92c
18+plus	9.58a
24+plus	8.82d

Data's are means of three replications, Means followed by the same letter in each column are not significantly different $p<0.01$, ns: not significant

The long term use of urban waste on the maize was searched in a study. The obtained results showed that the waste is a valuable nutrient source for maize nutrition (Wehrheim *et al.*, 2001).

Approximate increase ratios in N, P, K and Ca elements in terms of macro elements were 40-120, 35-65, 17-47 and 50-57%, respectively when compared to the control group at 24 ton da^{-1} waste and 24+plus applications (Table 6). When compared to control group the increases obtained in the waste plus chemical fertilizer applications were higher which shows that the urban waste water have nutrients in terms of macro elements. When the control group compared with the 24 ton da^{-1} waste and 24+plus applications, the increase ratio of Fe, Cu, Zn and Mn elements was 9-12, 420-510, 760-450 and 16-28%, respectively (Table 6).

When the protein content data of the grain is evaluated, it can be said that the protein ratios decreased slightly with the waste treatment doses in the first year of the experiment and that ratio increased slightly at the highest waste dose level (Table 7). The protein ratio of grain increased merely in waste treated group but it decreased slightly in waste plus chemical fertilizer treated group (Table 7). When considered generally, the increase of waste application doses didn't affect the protein ratio in the grain too much besides in the first year of the experiment little decrease occurred in the plus group. It can be explained as follows; long ripening period of grain results in an increase of starch so that protein ratio decreases in those plants.

CONCLUSIONS

In this study, which is about the use of urban waste water stabilized with lime in agricultural lands, it was determined that no significant change was seen in the soil pH and $CaCO_3$ and EC ratios whereas P and K contents of the soil increased. With the applications done in barley, a significant increase was seen in the nutrient elements (N, P, K, Ca, Fe, Cu, Zn and Mn) of the plant. Grain yield was at the highest level at the maximum waste application dose. Moreover fertilizer application together with the waste treatment resulted in favorably and increase in the yield was higher than before. While obtaining 233 kg da^{-1} yield with unfertilized 24 ton da^{-1} waste treatments, that amount reached up to 258 kg da^{-1} with fertilized 24 ton da^{-1} waste treatments.

Results shows that stabilized urban waste water can be used for fertilization and irrigation because of the fact that the nutrients that they include. After analyzing the soil structure and the needs of the plant that will be grown. Waste water can possibly be used by combining with fertilizer. In this way, it will be both an economic fertilization method and a recycled irrigation source.

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