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Investigation of Physico-chemical and Microbiological Characteristics of Urban Wastewater For Use in Agricultural Production

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Today, scarcity of water is one of the greatest challenges in agriculture. The reasons for this scarcity are population growth, promotion of lifestyle, climate change, continuous droughts, and lack of proper water resource management. under such circumstances, use of unconventional water sources including urban wastewaters in agriculture as the major consumer of water is of special importance. In this paper, quality of raw wastewater of Meshkinshahr, located in Ardabil Province, Iran, was studied, which is directly used in spring and summer in Brazil Village, a village in the southern part of the county, due to shortages of water sources for irrigation of orchards and farms. The present research is a descriptive-cross sectional study carried out by sampling from raw urban wastewaters in spring and summer 2014. The results suggested that average values of pH, DO, COD, BOD_5, TSS, Cr, Mg, B, Cd, Pb, Hg, Fe, parasite eggs, oil and fat, turbidity, nitrates, Ca, Mn, Na, Cl and phosphates were 7.05 mg/l, 2 mg/l, 412.5 mg/l, 235 mg/l, 92.5 mg/l, 0.0265 mg/l, 0.02 mg/l, 0.15 mg/l, 0.015 mg/l, 0.22 mg/l, 0.05 mg/l, 0.275 mg/l, 4.8 mg/l, 91.5 mg/l, 0.085 mg/l, 53.5 mg/l, 37 mg/l, 39.5 mg/l, 0 mg/l, 12.55mg/l, respectively, which are lower than agricultural standards of Department of the Environment (DOE). Average contents total and fecal coliforms were 3300mg per100ml and 2300mg per100ml, respectively, which were inconsistent with this standard. Thus, in order to avoid hygienic and coliform-based impacts, chlorinating the wastewater prior to its consumption for agricultural purposes is recommended to reduce the values to DOE standards.

Key words: Quality of wastewater, Physico-chemical, Microbiological, Agricultural Irrigation.

Today, world is facing the challenge of water scarcity. Limitation of water sources has attracted attention of researchers to proper use of unconventional water sources such as brine water and urban and industrial effluents. Due to urban development and increase in water consumption, a large volume of water is produced from raw wastewater and treated effluents. In Iran, a great deal of water used by major cities is converted to urban wastewaters (Tajrishi, 1998). While many arid and semiarid areas of Iran are exposed to scarcity of water sources, and water demands for irrigation are high. Under these conditions, usage of low quality sources is being considered. On the other hand, the urbanized areas produced huge amounts of wastewater, the inappropriate disposal of which poses environmental problems to the surrounding areas. Application of urban wastewaters in irrigation has been recommended as a rich source of fertilizing elements in many countries (Feigin et al, 1991). Wastewater can compromise human health through incidence of bacteriological, viral,

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protozoan and parasitic diseases. Fatta et al (2005) believed that application of wastewater in agriculture, provided it is sufficiently treated, will not cause nematode diseases among farm workers and consumers, unless climatic conditions and irrigation type prepares the environment for survival of nematode eggs. But, according to Shuval et al (1986), endemic ascariasis and trichuriasis in the world is coincided with application of wastewater for irrigation. In their epidemiological studies, these researchers also concluded that the risk of outbreak of ascaris worms in children and adults, who used wastewater-irrigated crops, is very high. They also point to diseases such as cholera, typhoid and shigellosis as a result of wastewater usage in farming. In addition to pathogenic microorganisms, domestic and industrial wastewaters contain a variety of chemical compounds including medicines, hormones, antibiotics, hormone-affecting compounds, etc., which their long-term impacts particularly via application of effluents in agriculture on human health and ecosystems are yet to be known (Fatta et al., 2005). Generally, wastewater leaves various biological, physical and chemical impacts. These impacts mainly result from physic-chemical quality of wastewater, which in case farms are irrigated with it, influence physical conditions of the soil of cultivated lands and assimilation capacity of micro and macro elements (Shariati, 1996). Irrigation with wastewater is taken into consideration as an option to offset shortage of available water. In this case, it is necessary to assess impacts of use of urban wastewater on physical and chemical properties to achieve sustainable development (Masoudi Ashtyiani et al, 2011). In Iran, based on a report by Shayegan and Afshari, out of 3.9 billion m^3 urban wastewater, only 9% are treated and the rest enter absorption wells, rivers and farms without any treatment (Shayegan and Afshari, 2004). During last century, water consumption rate increased heavily. Increase in consumption per capita and unplanned use of water sources has led to qualitatively and quantitatively critical conditions of water. Hence, usage of unconventional water sources including urban wastewaters, particularly in agriculture, which is the main consumer of water, is of especial importance. Many developing countries are not capable to use detailed wastewater treatment plans. Millions of farmers in these regions do the farming by using wastewater or wastewater-polluted sources, where there is no alternative for wastewater. Deleterious components in the wastewater can threaten environmental health and quality. Risk management and intermediate solutions are, therefore, necessary to prevent from adverse impacts in wastewater irrigation. A combination of control measures including control at source, control at farm level, and postharvest measures are applied to protect farmers and consumer (Shayegan, 2004). Due to high potential to hurt human and animal health, heavy elements such as Pb, Cd and Cr were highly taken into consideration in recent years and efforts have been made to prevent them from entering environmental cycles as much as possible (Sahebghadam Lotfi, 1988).

Since 1960, some studies were carried out about health hazards of projects using wastewater in irrigation. Also in 1968, wide research was conducted in Namibia with the aim of preparing drinking water from wastewater. Then, in 1970s and 1980s, potential of health hazards in reusing treated wastewater for irrigation and drinking purposes. In the last quarter of 20th century advantages of wastewater reuse was officially confirmed as an option in water resource development and became legitimate by United States and European Union. Use of wastewater for irrigation (due to high concentrations of heavy and toxic metals and their microbiological load) can disrupt ecosystem functioning (Naghshinehpour, 1994). Many developing countries are not able to use detailed treatment plans. Millions of farmers in the suburban areas of countries do the farming by using wastewater or waters polluted with agricultural wastewaters and they have no alternative. Deleterious components of wastewater can threat environmental health and quality. Risk management and intermediate solutions are necessary to prevent adverse impacts of wastewater. A combination of control measures including control at source, control at farm level, and postharvest measures to protect farmers and consumers (Qadir et al.,2010). In "study of the impacts of irrigation with urban wastewater on soil and growth of pine trees in Tehran" Salehi et al (2007) concluded that utilization of urban wastewater could be a source of water for afforestation. Naseri (1999) in “study of methods, health criteria, and wastewater reuse project management” conclude that considerable amounts of materials such as phosphate, potassium hydroxide, and Nitrogen, which all play a vital role in fertilizing arable lands, effectively increase crop production. On the other hand, new lands will be cultivated in order to supply water for agriculture leading to emigration of the farmers.

MATERIALS AND METHODS

According to existing meteorological data, average annual rainfall in Meshkinshahr City located west of Ardabil Province, northwest of Iran is 390mm. This city lies in a mountainous area with temperate and relatively cold weather and most crops are irrigated, which is exclusively supplied by surface waters, wells, and springs.

This is descriptive-cross sectional study that sampling from raw urban wastewater was directly preformed in orchards and farms in spring and summer to determine levels of important parameters in irrigating agricultural crops in orchard and farm inlets in spring and summer (May to August). Sampling was carried out based on Standard Method (2008). Samples were analyzed in creditable laboratories of Ardabil Province (Okinchi) and East Azerbaijan (Haghdar in Miyaneh and Kolor Pars). Samples for microbial and biological tests were kept in 4° C and were transferred to the laboratory in at most 6 hours. The samples for heavy metal measurement were transferred to the laboratory after nitric acid was added. Some parameters including DO, temperature, and pH were measured onsite by portable 156 sension hach. Excel and SPSS16 were used to draw the graphs and statistical analyses.

RESULTS AND DISCUSSION

A variety of standards about different applications of effluent has been set by international organizations such as FAO, EPA, and WHO. In Iran, the standards of the use of wastewater in agriculture and irrigation were set by DOE. Decisions on potentials of wastewater reuse I various options have been made based on results of tests conducted on raw urban wastewaters in Meshginshahr and its comparison to DOE standards (Table1). Since the values obtained in four times of sampling were not considerably different, the average measured values (Table1) were compared to national standards.

As seen in Table1, average values of total coliform and fecal coliform in urban waterwaters in Meshginshahr were 3300mg/l and 2300 mg/l, respectively. Therefore, these values are far beyond the values recommended by DOE (1000mg/l, 400mg/l). Average values of pH, DO, COD, BOD_5, TSS, Cr, Mg, B, Cd, Pb, Hg, Fe, parasite eggs, oil and fat, turbidity, nitrates, Ca, Mn, Na, Cl and phosphates were 7.05 mg/l, 2 mg/l, 412.5 mg/l, 235 mg/l, 92.5 mg/l, 0.0265 mg/l, 0.02 mg/l, 0.15 mg/l, 0.015 mg/l, 0.22 mg/l, 0.05 mg/l, 0.275 mg/l, 4.8 mg/l, 91.5 mg/l, 0.085 mg/l, 53.5 mg/l, 37 mg/l, 39.5 mg/l, 0 mg/l, 12.55mg/l, respectively, which are consistent with DOE standards. Results of sampling for these parameters in comparison with DOE standards are grouped separately as heavy metals (Diag.1), biological parameters (Diag.2), nutrients (Diag.3) and anions and cations (Diag.4).

Selection of suitable plants to be irrigated by wastewater should follow some principles to avoid infection of the crops with pathogens and transferring them to consumers. Thus, considering direct use of raw wastewater in Meshkinshahr and the obtained information of its quality, irrigating vegetables and crops, which are eaten uncooked, is not recommended. Also due to direct contact with soil, irrigating rooted plants such as potato, wheat, barley and beans, which are consumed directly, is not recommended. Therefore, when raw wastewater is conveyed to the treatment plant and coliform contents are reduced to a standard level for agricultural purposes, effluents of Meshkinshahr treatment plant could be used in agriculture.

Irrigation of orchards, where fruits are consumed freshly; trees, which their crops are used in the form of nuts; wooden trees including cedars, pines, elms, and spruces, as well as industrial crops such as cotton are not recommended because of soil contamination. Irrigating green fields and public places are not

Table 1. A comaprison of the quaity of raw urban wastewater in Meshginshahr with DOE standards for irrigation and agricultural purposes

DOE standards for irrigation and agricultural purposes	average measured values	unit	Parameter	no
6-8.5	7.05	-	pH	1
2	2	mg/L	Do	2
100	235	mg/L	BOD5	3
200	412.5	mg/L	COD	4
100	92.5	mg/L	TSS	5
-	619	s/cm µ	EC	6
-	420.5	mg/L	TDS	7
-	1.0126	ML/LIT	SAR	8
0.1	0	mg/L	Remaining chlorine	9
400	2300	MPN/100mL	Fecal coliform	10
1000	3300	MPN/100mL	Total coliform	11
Bylaws 5	0	Count	Parasit eggs	12
-	53.5	mg/L	Ca	13
100	37	mg/L	Mg	14
-	39.5	mg/L	Na	15
-	11.8	mg/L	Nitrate	16
-	12.55	mg/L	Phosphate	17
1	0.0265	mg/L	Cr	18
1	0.15	mg/L	Br	19
1	0.02	mg/L	Mn	20
0/05	0.015	mg/L	Cd	21
1	0.22	mg/L	Pb	22
little	0.05	mg/L	HG	23
50	91.5	NTU	Turbidity	24
10	4.8	mg/L	Fat and oil	25
1	0	mg/L	Phenol	26
-	52.95	mg/L	Ammonia	27
3	0.275	mg/L	Fe	28
-	0.085	mg/L	Nitrite	29
4	11	mg/L	Choride	30

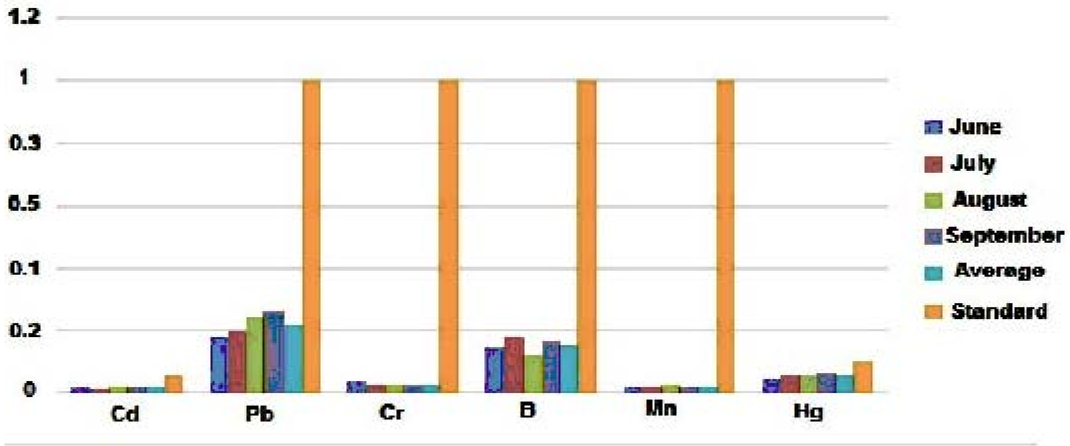

Fig. 1. Comparison of heavy metal (Cd, Pb, Hg, Cr, Mn, and B) contents in Meshkinshahr with DOE standards for usage of wastewater in agriculture

recommended either. Although concentrations of heavy metals are lower than the thresholds recommended by DOE, accumulative impacts of these elements make irrigating nonedible industrial crops such as cotton and wooden trees. At present, direct and unplanned use of raw wastewater in downstream areas of Meshginshahr is for farming, hence, in order to protect farmers' and villagers' health, these sources should be available for farmers in a planned manner by transmission to the treatment plant to be chlorinated to meet DOE standards regarding total and fecal coliforms.

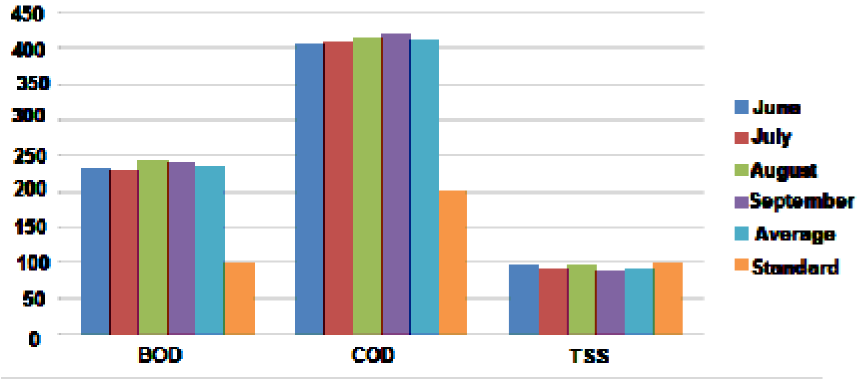

Fig. 2. Comparison of BOD_5, COD and TSS with DOE standards in Meshkinshahr wastewater

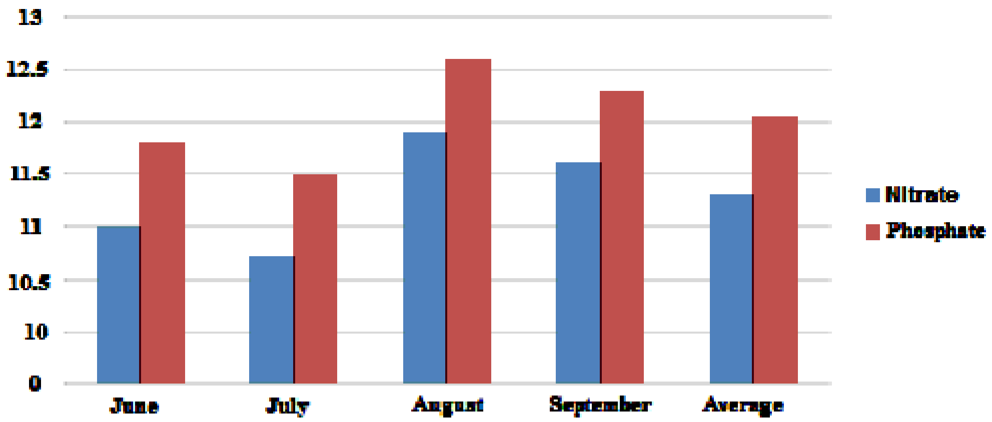

Fig. 3. Contents of Nutrients (phosphate and nitrate) in Meshkinshahr wastewater

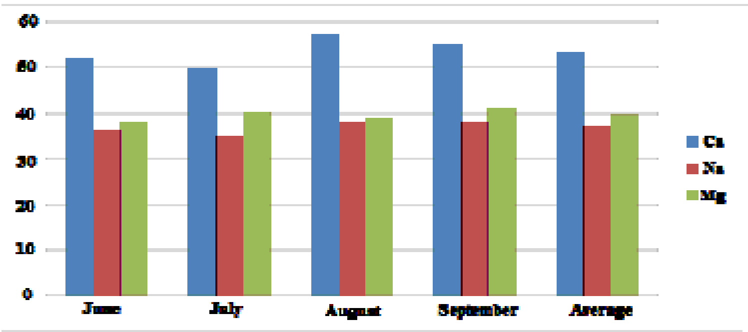

Fig. 4. Contents of Ca^{2+}, Mg^{2+} and Na^{+} in Meshkinshahr wastewater

CONCLUSIONS

The results showed that average values of pH, DO, COD, BOD_5, TSS, Cr, Mg, B, Cd, Pb, Hg, Fe, parasite eggs, oil and fat, turbidity, nitrates, Ca, Mn, Na, Cl and phosphates were 7.05 mg/l, 2 mg/l, 412.5 mg/l, 235 mg/l, 92.5 mg/l, 0.0265 mg/l, 0.02 mg/l, 0.15 mg/l, 0.015 mg/l, 0.22 mg/l, 0.05 mg/l, 0.275 mg/l, 4.8 mg/l, 91.5 mg/l, 0.085 mg/l, 53.5 mg/l, 37 mg/l, 39.5 mg/l, 0 mg/l, 12.55mg/l, respectively, which are consistent with DOE standards for use of wastewater in irrigation and agriculture. Only average contents of total and fecal coliforms were 3300mg per100ml and 2300mg per 100ml, which was higher than DOE standards.

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