Sewage dilution as a management alternative in agricultural reuse of wastewater

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ABSTRACT

Wastewater is used as a source of irrigation water as well as a source of plant Nutrients, allowing farmers to reduce or even eliminate the purchase of chemical fertilizer. Furthermore performance of wastewater treatment plans Is expensive and cost involves.
Hence take a method that reduce costs and health risks in wastewater reuse is an interesting alternative that is considered in this scheme, there is the most emphasis on possibility of blending use of the raw wastewater and Freshwater in corn production.
Applied maize variety in this plan was «MAIZE-704» that is commonly cultivated in this zone, calculation of consumptive use for this crop is estimated by FAO-Penman-montith method that resulted 3.25 mm/day.
Irrigation water requirements for all treatments was the same (3.25 mm/day) .
The irrigation treatments were:
T_1 - raw sewage T_2 - Secondary treated effluent
Dilution portions:
T_3 - 75% sewage and 25% freshwater
T_4 - 50% sewage and 50% freshwater
T_5 - 25% sewage and 75% freshwater
T_6 - completely well water and traditional fertilizers
Result showed that the T_1 (raw sewage) had the best yield with 11880 kg/ha and after T_5 with 10450 kg/ha.

Keywords: Wastewater, Dilution, irrigation, Water resources, Management

1. INTRODUCTION

Population growth and higher living standards will cause ever-increasing demands for good quality municipal and industrial water, and ever increasing sewage flows. At the same time, more and more irrigation water will be needed to meet increasing demands for food for growing populations (Bouwer, 2000).

Water scarcity is privilege problem in arid and semi-arid areas. There are different ideas for solving water shortage in these areas. Collection sewage water and reuse in agricultural areas, after treatment, is one alternative that can be used in dry lands.

Reuse of wastewater as irrigation water is one of the ways for solving the problem due to the water shortage. In this case wastewater is as source of irrigation water as well as a source of Plant nutrient, allowing farmer to reduce or even eliminate the purchase of chemical fertilizer.

Apart from the natural scarcity of freshwater in various regions and countries, the developing countries in particular, the quality of the available freshwater is also deteriorating due to pollution, hence intensifying the shortage. It is estimated that today throughout the world, more than 5 million people (mostly children) die annually from illnesses caused by drinking poor quality water. The number of people lacking access to safe drinking water, mainly in developing countries, will increase between two and three billion in the year 2000 (Stikker, 1998).

Liquid wastes such as untreated sewage or industrial waste are the major sources of pollutants in developing countries. Municipal sewage and industrial wastewater containing readily biodegradable organic matter, inorganic and organic chemicals, toxic substances and disease causing agents are frequently discharged into aquatic environments (oceans, rivers, lakes, wetlands) without treatment. This unregulated practice results in contamination of water that is then unsuitable for human consumption, land irrigation, fish production or recreation. In rural areas and unplanned high density urban settlements, contamination of surface and groundwater by domestic wastewater occurs through infiltration and surface run-off of poorly placed pit-latrines especially during the rainy-season (Denny, 1997). The situation is getting worse with rapid urbanization and a continuing lack of proper sanitation in developing areas. Increased use of fertilizers in agriculture is also contributing significantly to non-point source pollution through run-off.

Wastewater is a preferred unconventional water source, since the supply is increasing because of population growth, there is enhanced awareness of environmental quality, and its costs are relatively low. Urban sewage must be treated to adapt it to agricultural uses, but treatment is also essential for safe environmental disposal, therefore, the relevant costs of wastewater for agricultural reuse are just the additional costs needed for adaptation to agriculture (Sadan E, Haruvy N, 1994). Wastewater can serve as a source of both water and nutrients, thus also reducing fertilization costs.

Benefits of agricultural reuse of wastewater are expressed when agricultural production is maintained while water sources and environmental qualities are preserved. At the same time, wastewater irrigation may be hazardous to the environment, since the influent and hence the effluent contains pollutants such as macro- and micro-organic and inorganic matter. Macro-organic matter including biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total suspended solids (TSS), micro-organic pollutants, trace elements, pathogenic microorganisms, macro-nutrients (nitrogen, phosphorus) and salinity. These constituents way harm the environment, health, the soil, aquifers and crops (Feigin et al 1990), (US EPA, 1992). Any decision making related to wastewater reuse should consider both aspects: benefits and hazards. Hazards can be decreased by improving effluent quality and-or conveying effluents to distant locations, both of which involve increased costs. An optimal decision-making procedure aims at maximization of net national benefits, i.e., benefits minus costs and minus

the value of environmental damage (Haruvy N, Sadan E, 1994). The complex considerations involved in wastewater agricultural reuse are described by (Haruvy N, 1997).
The present paper focuses on regional considerations of whether and whither to transfer effluents. Treated effluents need not be discarded or used for irrigation near their point of origin; they may be conveyed to other locations because of local surplus and-or environmental impacts. The supply of wastewater is determined by the density of population in a specified region, and this density determines the prices of land in general and-or the availability of agricultural land in particular. Hence, metropolitan areas produce wastewater surpluses, while peripheral areas may exhibit deficits. To preserve environmental quality, surplus wastewater should be disposed of to surface water bodies, or conveyed to other locations for agricultural use.

Water is considered a limited and vulnerable resource, essential for life. In general, interest in resource recycling increases. Agricultural land is now an alternative disposal route for wastewater. In this situation, wastewater components are used productively to supply crop growth with nutrients. The main problem with wastewater utilization for irrigation in agriculture, apart from the possibility of it containing hazardous constituents, such as trace elements and organic compounds, is the risk of polluting groundwater. Furthermore, waste-water used on farming land increases the possibilities of damaging the productivity of the soils in the long run. (Mavrogianopoulos et al. , 2002).

Agricultural wastewater reuse is an element of water resources development and management that provides innovative and alternative options for agriculture. Reuse of reclaimed water for irrigation enhances agricultural productivity: it provides water and nutrients, and improves crop yields. However, it requires public health protection, appropriate wastewater treatment technology and siting, treatment reliability, water management and public acceptance and participation. It must also be economically and financially viable. (Bahri, 1999)

In 1973, the World Health Organization (WHO) proposed relatively stringent guidelines: the quality of the effluent to irrigate crops to be consumed raw had to be high and close to water supply quality. These recommendations were based on the concept of "zero risk". To achieve such a level implies very important investments. Few countries have developed reuse projects in compliance with these guidelines. The epidemiological approach for health risks assessment allowed an evolution of the wastewater reuse guidelines. In 1989, new guidelines were issued by WHO for aquaculture and non-potable urban uses. They take into account the treatment process, the irrigation system, the exposed group, and the crops to be irrigated. This new set of guidelines is controversial but has allowed a real development of wastewater reuse.

2. WASTEWATER TREATMENT

Before designing a wastewater treatment plant, the final end uses of the water should be first considered. The treatment objectives and standards need then to be clearly defined. This will lead to reconsidering the treatment approach, required treatment levels and processes, and the indicators that should be taken into account. It may also reduce conflicts of interest between wastewater producers and users due to the objective difference among each group. But reuse has so far not been considered as an objective sufficiently important to modify our approach to treatment and disposal practices. Conventional technology has been adopted for treating wastewater independently of the type of reuse. The performance criteria that are appropriate for a given type of reuse are generally not carefully considered.

Wastewater treatment cannot be based on the same approach as water supply because of the variety of existing reuse opportunities. Wastewater treatment must be linked to the type of reuse. The general approach adopted up to now is based on producing an effluent in compliance with water quality discharge requirements. Treatment plants are designed with no concern for reuse and there are no guarantees for the quantity or quality of the effluent. Reuse is generally considered in a second step. It is rarely the starting point. For agricultural reuse, conventional treatment plants, such as activated sludge processes, are generally designed for pollution control with BOD and SS removals as main objectives and the standards for these parameters are often higher than required; on the contrary, these conventional systems are ineffective to remove helminthes eggs, bacteria or viruses. So, the approach to treatment generally adopted is not how to make the best use of the water components which means, first, how to keep nutrients and get rid of microorganisms and the undesirable components, and, second, what would be the most appropriate technology for such a target. The application of performance criteria that describe the desired effects on human health (reduced exposure to pathogens), environment (ecosystems to be protected), and human activity (agriculture, in the specific case) would be a more innovative approach (Krauss and Boland, 1997). The setting of water quality objectives depending on the type of reuse has to be the result of a balance between what is desirable form an environmental and public health point of view and what is feasible from a technical and economic point of view.

Irrigation management. In arid and semi arid areas, sewage effluents are often salt-affected for various reasons, such as the seepage of brackish/sea water into the sewerage network, the location of treatment plants, the proportion of industrial water compared to the domestic, and finally water supply quality (Bahri, 1995). This implies specific management measures such as the selection of agricultural crops resistant to lower water quality, the selection of the most appropriate irrigation and drainage techniques (application of leaching fraction, etc.), the adoption of specific cropping techniques, etc. (Ayers and Westcot, 1985; Pettygrove and Asano, 1985; Kandiah, 1990). Water and salt leaching requirements need to be known more precisely to avoid water losses and more studies on solute transport have to be conducted to prevent groundwater pollution. In Mediterranean areas, permanent leaching does not improve yields much. By an appropriate scheduling of leaching (autumn or winter during the rainy period), less water is needed to obtain a good leaching efficiency. However, the major problem is generally first to improve water use efficiency. This may be achieved through a more accurate knowledge of crop water requirements for irrigation scheduling and the use of water saving application methods such as drip irrigation systems. These systems would be, when filtration is adequately performed, the safest way of using reclaimed water and preventing microbial contamination. However, such systems cannot be used in several cases such as extensive crops (alfalfa, wheat, etc.) and golf courses. Where reuse schemes are aimed at achieving maximum economic returns, studies are also still required to determine optimal cropping patterns and sequences.

Fertilization. The quantification of nutrients supplied by effluents is rarely done in the reuse areas. Effluent composition needs to be regularly monitored in order to estimate how much nutrients they supply and how much should be supplemented in order to match crop requirements. Farmers often do not take into account the amount of nutrients supplied by the effluents or by the soil. High amounts of residual nitrogen may still be available in the soil at the end of the vegetation period that constitutes a risk of N leaching (Bouwer, 1990). Research is needed in this field to achieve nutrients savings and recycling and to prevent over-fertilization problems and groundwater pollution.

2.1 Material and Methods

The aim of this research was to study the yield of maize that was irrigated by untreated municipal wastewater. The place of this research was field research of Irrigation Dept., Agriculture Faculty- Tehran university, Karaj –Iran. The research place was in 35.5 degree latitude and 50 degree longitude. The elevation of this place was 1291 meter above the sea

levels. According to the Demarten classification this area has Semi-arid condition. Average annually precipitation was 256 millimeter. Mean average temperature was 14.7 centigrade. In this study, applied maize variety in this plan was MAIZE-704 that is commonly cultivated in this zone.
For irrigation in this plan six cases were considered. In each case especial mixed of raw wastewater with good water were used. After cultivation and Irrigation Yield in these case are different. We consider six cases as following.
T_1 = Irrigation with raw sewage T_2 = Secondary treated effluent
In other cases Sewage diluted with freshwater with different dilution portions:
T_3= 75% sewage and 25 % well water
T_4= 50% sewage and 50% well water
T_5= 25% sewage and 75% well water
T_6= Completely well water
In this plan irrigation water requirement and irrigation period for corn was calculated. This amount of water for all cases equal was considered.
Irrigation period 7 days was calculated.

This experiment was conducted in a Complete Randomized Block design in the plots with dimension of 3_m *3_m and in 3 replications in the field of Agriculture Collage of Karaj. The water volume used for all replications were the same.

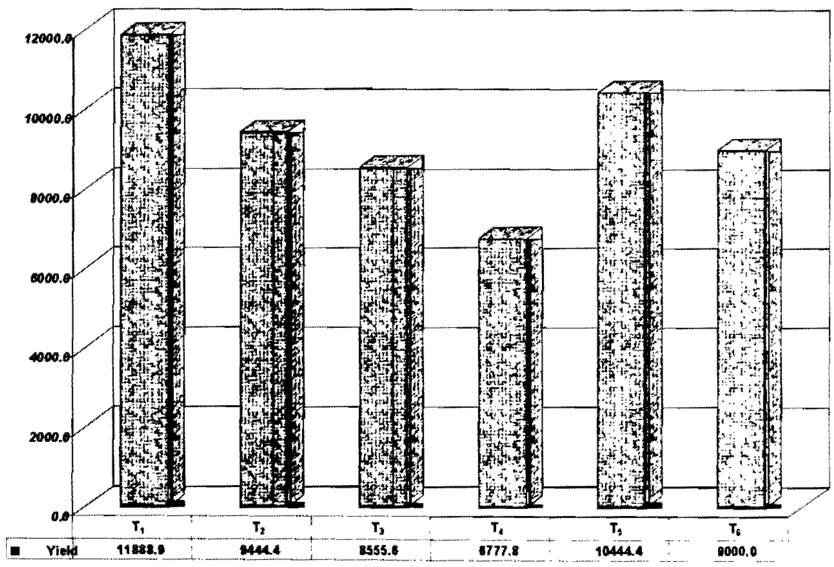
Date of Planting according to the region was in the middle of March and the date of harvesting was in the middle of September. During the growth period four times were sampled. For statistic analysis of results from SAS software was used.
Metal elements concentration and macro element concentration were measured by flame photometer and Spectrophotometer.
Raw wastewater required for this plan prepared from 35 km far from the field test. This wastewater was conveyed by one tank with 2000-litter volume.

3. RESULT AND DISCUSSION

3.1 Effects on yield

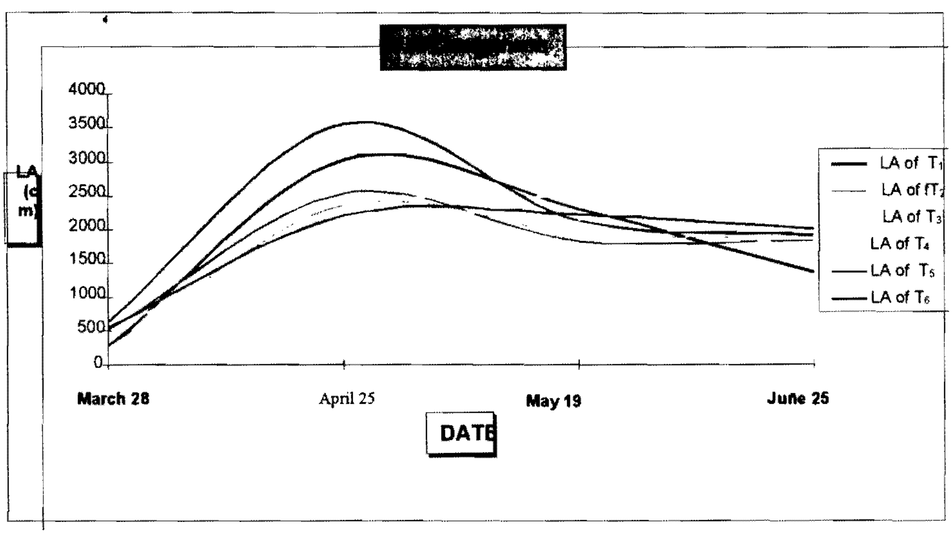
The most yield production belongs to case T_1, raw sewage, as it was shown in Fig 1.
In T_1 average yield production was 11888 Kg/ha. It had 2 % difference with case T_5. The other points that it was shown in Fig1 is that from case T4 to T1 yield decrease. This decrease did not linearly. Yield production in case T_2 was after T_1.

Figure 1: Effects on yield



3.2 Effects on Leaf Area Index

The effects of raw wastewater and proportional mixture with freshwater on Leaf Area Index only in case of raw wastewater had 100% difference with evidence case. This difference was shown in Fig 2. Since besides the usage of corn seeds it could be used by domestic animals. Therefore, LAI had importance role. In this experiment the smallest leaf area growth belongs to case T_5, 25% raw wastewater.

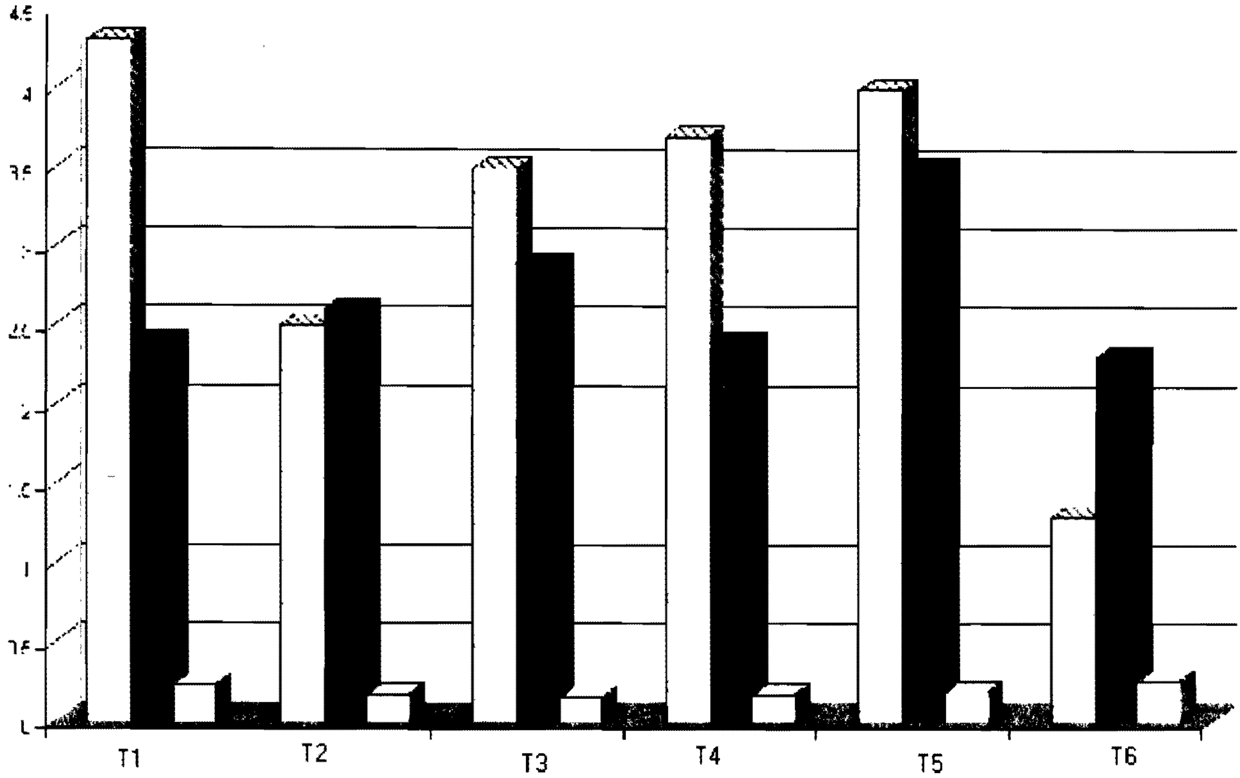


3.3 Effects on NPK absorption

For nitrogen there is general rule that when amount of N in soil is high therefore N in plant also is high. But in this research only in case T_1, using wastewater treated, is correct and for the other cases N concentration from T_2 to T_5 is increasing.

P is from main elements and important element in crop production. There two form of P, organic and inorganic forms. Plants mainly adsorb P in the form of orto-phosphate. Therefore, irrigation with wastewater plant available P was increasing. But, there was no importance difference in adsorption variation.

There is Potassium in plant as adsorbed ion. Result of this test shown that in all cases except T_5 there is not such difference.



3.4 Results

This research shown that usage of raw wastewater cause considerable increasing corn yield in Maize. Besides, the using of this wastewater cause considerable increasing in LAI that it is important for domestic animal point of view.

With water shortage the usage of raw wastewater mixed with freshwater, as irrigation water, is an alternative for decreasing problems due to the water scarcity in arid and semi-arid areas.

This research shown that case T_5 which contains 25% raw wastewater and 75% well water after case T_1 gave the best result from yield and element adsorption from point of view. With this percent mixture, the dangerous of using wastewater from pathogenic microorganism point of view will decrease.

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