CROP GROWTH AND SOIL PROPERTIES AFFECTED BY SEWAGE WATER IRRIGATION - A REVIEW.

S.R. Ambika, P.K. Ambika* and Govindaiah
Department of Life Science, Bangalore University, Jnanbharathi Campus, Bangalore- 560 056, India

ABSTRACT

Water is becoming the most important limiting natural resources now a days. Hence, its multiple use and re-use is becoming more and more important to meet the increased demand of agricultural production. Sewage water have a high nutrient load, suspended solids, dissolved nitrates, pesticides, heavy metals and many other toxic materials / chemicals which may be hazardous and it may effect the soil micro-flora, soil texture and quality and also the plant growth and development. Studies by different authors on different agricultural crops, on the effect of sewage water irrigation on plant growth, quality, soil nutrients, properties and micro-flora are reviewed in this paper.

Key words: Heavy metal contamination, Plant growth, Sewage water, Soil micro-flora.

Water – a limiting natural resources:

Even though three fourth of earth’s surface is covered with water, only three percentage of it is available for the use of mankind. About 97% of earth’s water is saline and in the remaining fresh water, 68% is locked up in ice and glaciers, 30% is in the ground and the remaining constitute the surface water(Gleick,1996, Howard Perlman, 2009). Begum et al (2008) stated that about 95% of the earth’s water is in the ocean, 4% is locked in the polar ice caps and remaining 1% constitutes in hydrological cycle including ground water reserves. Only 0.1% is available in as fresh water in rivers, lakes and streams which is suitable for human consumption. India supports about 1/6th of world population, 1/50th of world’s land and 1/25th of world’s water resources. It has a livestock population of 20% of world’s total livestock population. The total utilizable water resources of the country are assessed as 1086km³(Kumar et al., 2005). With increasing population, demand and utilization of water is also increasing. Basically India has an agriculture based economy, hence more than seventy percentage of water is being utilized for the irrigation (Kumar et al., 2005). We require effective management techniques for a better utilization of the limited natural resources like water. Shortage of surface and underground water could be partially overcome by reuse or recycling of water. Currently, recycling of water is not practised on a large scale in India. Estimates show that recyclable water is between 103 and 177 km³/year for low and high population projections (Kumar et al., 2005). A huge quantity of waste water is being generated from cities and other industrial areas which is flowing, as a river or joined with streams, towards the village where most of the people are earning their lively hood through Agriculture. Most of the farmers, who have fields near the banks of these sewage canals are using this as a source of irrigation and pumping/flooding water directly to their field.

*E-mail: ambika.pkrishnan@gmail.com
As the population increases the urban sewage flow also increases and it is becoming a necessity to treat and reuse the waste water with proper planning and control to reduce the pollution of surface water and ecosystem. Oster (1994) suggested three changes from standard irrigation practices such as; selection of appropriate salt tolerant crops, improvement in water management and adoption of advanced irrigation technology and maintenance of soil physical properties for sewage water irrigation as the total salt content and sodium content of this water are higher than normal sources. Larrick and Bowersox (1999) in their study on long term effects of waste water irrigation on forested ecosystem at Pennsylvania observed a difference in species composition and structure between irrigated and non irrigated area species of tree, shrub and herbaceous plants. They suggested modifications to either the plant community species base or the methods of waste water distribution to maintain forested ecosystems in the waste water area. Bouwer (1994) in his review paper, stressed about the need of water management on local, regional, national and international level. This include providing more storage of water during surplus time, minimizing water losses, increasing production per unit of water and reusing waste water.

### Sewage water as a source of irrigation:

Study on the economic effect of sewage water irrigation on suburban farms of Beijing indicated 9.3% increase in agricultural production value, savings from polluted water processing is 49.7% and clean water consumption is 27.6%. Economic benefit from sewage irrigation is sustained at the expense of environment (Zhixin et al., 2007). Treated waste water is an important source of nutrients and can be used for irrigation under controlled condition (Jimenes-Cisneros, 1995 and Angin et al., 2005). Yadav et al. in 2003 studied the different physico chemical and biological parameters of sewage water collected from different towns of Haryana and observed considerable variation among different districts and in different seasons. They also reported that the effluent has the capacity to contribute cumulative nutrients (N,P,K, Zn, Fe and Cu) of approximately 56.4 tons/day.

Usually most sewage effluents from residential areas will meet the standards for irrigation water, except for the presence of some chemicals. Now-a days, in some areas around urban cities the untreated waste water or sewage water is directly used for irrigating different crops which may raise some public health hazards like the outbreaks of some dangerous epidemics. Most important parameter in sewage water is the different microbial populations which can cause various diseases. Waste water is likely to contain high levels of bacteria, parasitic organism and other pathogens as well as heavy metals (Srikanth et al., 1994). The use of untreated waste water and water supplies contaminated with sewage for irrigation has been implicated as one of the important resources of pathogenic micro-organisms contaminating vegetables (Doyle, 1990; Islam et al., 1990 and Wei et al., 1995). Consumption of such vegetables has resulted in outbreak of diseases. It is better to use treated sewage water rather than the raw sewage water to irrigate food crops such as vegetables, cereals, etc. to remove or control the pathogenic contamination. There are reports that sewage water can be treated to obtain safe irrigation water and non potable water. Asano et al. (1992) suggested primary and secondary treatment followed by coagulation, sand filtration and chlorination for this purpose. But this method is quite costly. However the ground water recharge with infiltration basins suggested by Bouwer, 1985 is a ‘low technology’ treatment for purifying sewage water. This can improve the quality of sewage water which can further be used for unrestricted irrigation and most other non potable purpose.

The agronomic and economic benefits and adverse effects of waste water or sewage water irrigation for different agricultural and horticultural...
crops were studied immensely. Many reports (Nagaraja and Krishnamurthy, 1987; Arar, 1988; Omran et al., 1988; Arshad et al., 1999; Zaghloul and Atta-alla, 2001; Lal et al., 2003 and Rija et al., 2005;) stated an increase in plant growth and productivity due to the high nutrient content in the sewage water. However, there are also reports on the health hazards and soil contamination due to waste water irrigation (Endtmann, 1976; Zaim and Newson, 1980; Morishita, 1988; Yadav, 2003;).

Effect of sewage irrigation on plant growth:

Recycled waste water effluent is an important source of irrigation in arid and semi-arid regions. Irrigation water quality is one of the main factors limiting the plant growth. Reuse of waste water must be planned better in the future as the sewage flow is increasing day by day. Due to the high nutrient content, farmers are benefited with high yield on the sewage water irrigation with less fertilizer inputs. Patel et al. (2007) and Al-Nakshabandi et al. (1997) reported in their study with Dill seed plant (Anetheum graveling) and egg plant (Solanum melongena) which were irrigated with sewage and tube well water, a significantly higher yield for the treatment which received sewage irrigation. A significant increase in the biochemical constituents like protein, carbohydrate and aminoacid contents in the fodder grass irrigated with sewage water during summer season was reported by Girisha et al. (2007). Similar result was reported by Rija et al. (2005) in their study of sewage irrigation on plants like Vigna radiata, Cicer arietinum and Lens culinaris. They recorded an increase in total protein, carbohydrate and chlorophyll contents in L. culinaris and C. arietinum leaf samples. An increase in above ground dry matter yield of fodder cabbage was reported by Szewazuk et al. (1996) without a significant increase of the microelement content in leaves, stem and roots. Further, Szewazuk et al. (1999) reported an increase in the growth rate of polish and Danish Osier willow in the first year of their study with partially treated municipal sewage water irrigation. In the second year only the Polish form showed positive growth. Celery plants irrigated with whole sewage water along with 50kg N/ha produced highest seed yield/ha and returns (Mahajan et al., 1978).

Studies on the utilization of sewage water for irrigation of various crops was initiated since 1940s. In 1966, Ramati et al. found that the perennial grassland crops developed well on shifting to sand irrigated with sewage water without manure or mineral fertilization. Both perennial and annual crops (maize, peas and cotton) produced yields equal to those on fertile soil. Kiziloglu et al. (2007) in their study on cabbage plants irrigated with waste water, reported that the waste water and preliminary treated waste water significantly affected the soil chemical properties up to 0-30cm soil depth and plant nutrient contents after one year. Waste water application increased yield, macronutrients and micronutrients of cabbage, soil salinity, organic matter, Na, K, Ca, Mg and P, micronutrient etc. and decreased soil pH. Another study on Gladiolus (Zaghloul et al., 2001) with secondary treated sewage effluent, sewage sludge and cement dust showed that the sewage water irrigation resulted in earlier flowering and increased fresh weight of corns compared with river water irrigation. Wang et al. (2007) studied the soil property, crop yield and quality, leachate etc. with seven crops such as celery, wheat, maize, millet, apples, rapeseed and yellow beans and found that the quality of crop did not vary significantly between treated and untreated sewage irrigated crops. An increased water salinity resulted in reduced fruit size and water content of Tomato where as it caused an increase in soluble solids, carbohydrate, total carotenoids, lycopene, Na and Cl2 concentrations (Pascal et al., 2001). Osman et al. (1997) reported a significantly lower grain yield of barley irrigated with drainage water. Similar reports of lower growth and yield of tomato plants irrigated with sewage water was reported by Xinming et al. (2007). Continuous irrigation of sugarcane with sewage water showed high yield without any deterioration of plants (Talati, 1942).
**Effect of sewage irrigation on heavy metal contamination:**

Sewage water often have a high nutrient load, suspended solids, dissolved nitrates, pesticides, heavy metals and many other toxic materials / chemicals which may be hazardous and it may effect the soil micro-flora, soil texture and quality and also the plant growth and development. Effect of its direct use for irrigation needs thorough study. Rattan et al. (2005) studied the long term impact of irrigation with sewage effluents on heavy metal content in soil, crops and ground water and found that sewage water contain much higher amount of P, K, S, Zn, Cu, Fe, Mn and Ni. Compared to ground water. Similar study was reported by Malla et al. (2007). A study on the effect of sewage irrigation on distribution of Pb and Cr in soil and plants was conducted by Ghafoor et al. (2005) and reported considerably high concentration of Pb and Cr in surface soil and above safe levels in crops. Copper is an essential micronutrient for plant growth, at the same time a heavy metal to be considered in soil contamination because its high concentration in soil produce toxic effects and may accumulate in plant tissue. A study on the sorption and fractionation of copper in soil at a sewage irrigated farm in Australia showed that the soil in the land filtration area has a high sorption capacity for copper (Li et al., 2006). The study conducted by XiBai et al. (2007) in soils of vegetable growing lands in China showed the highest heavy metal contamination in industrial effluents/sewage irrigated vegetable lands. Accumulation of heavy metals in different parts of plants such as wheat, carrot and spinach was reported by various authors (Chakraborthi et al., 1988; Adikari et al., 2004; Khan et al., 2006).

**Effect of sewage irrigation on soil microbes:**

Soil fertility is greatly influenced by the activities of micro-flora present in it and any alteration or contamination of soil will affect the micro-flora. Due to the scarcity of ground water, farmers are using raw sewage water more frequently for irrigation. This may effect the soil microflora as it contains many toxic materials and pathogens. The study conducted by Das et al. (2003) indicated that the use of raw sewage water directly is harmful to the growth of heterotrophic soil micro-flora, which are responsible for proper breakdown of soil organic matter for better plant nutrition. In a survey conducted by Andrew Bradford et al. (2003) on waste water irrigation in Hubli-Dharward, it was revealed that farmers staying close to cities have adopted a year round intensive vegetable and horticultural farming using waste water irrigation. Even though this increased the production, they reported the adverse health implications including soil bacterial contamination of vegetables. Health effects of waste water reuse for Agriculture was studied by Srikanth and Naik (2004) and found heavy contamination of vegetables by faecal Coliforms and Giardia cysts as well as other pathogenic bacteria such as Shigella and Salmonella was showed by sewage water irrigation and intake of raw vegetables like lettuce, cabbage etc. appears to be the cause of giardiasis, amoebiasis and diorrhea in the farming community and surrounding areas. Filip et al. (2000) reported highest no. of bacteria, actinomycetes, ATP content and enzyme activities in long-term sewage water irrigated soil than control. Study on pathogenic contamination (Minhas et al., 2006) in some sewage irrigated vegetable, forage and cereal grain crops showed highest bacterial plate counts in fodder crops. Pathogenic load reduced after sun drying in the field and health hazards could be reduced by adopting low cost practices like repeated washings, sun drying, raising crop bed, cutting above ground level for fodder crops etc. Zhang et al. (2008) in their study on effect of long term sewage irrigation on Agricultural soil in China, reported a higher utilization of carbon sources and diversity of microbes in sewage irrigated area. Weinberg et al. (2004) reported that the forage crops irrigated with sewage water were not likely to pose health risk to cattle if the ensiling process is adequate.
CONCLUSION

The Agricultural and industrial activities need to be in a continuous growth to meet the increasing demand for food and water supply for the fast growing world population. Where as the natural resources like water is not increasing with the demand, rather there is a gradual decline in availability of fresh water to be used for irrigation in developing countries like India. In future, the major dispute or competition among states or nations may be for water and we may have to invest more money and time for water management. Recycled waste water effluent is an important source of irrigation in arid and semi-arid regions. Irrigation water quality is one of the main factors limiting the plant growth. Sewage water often have a high nutrient load, suspended solids, dissolved nitrates, pesticides, heavy metals and many other toxic materials / chemicals which may be hazardous and it may effect the soil micro-flora, soil texture and quality and also the plant growth and development. Effect of its direct and long term use for irrigation needs thorough study.

REFERENCES


