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WASTEWATER FOR REUSE

INTRODUCTION

A crucial problem facing most countries in the 20th century is the acute shortage of adequate quantity and quality of water supply to meet the basic and various requirements of man. This is particularly very serious in semi-arid and arid regions of Africa and also in countries with temperate climate where communities are constantly in search of alternative sources to meet their demands. This problem has been aggravated in the savanna belt of West Africa by the recent drought which has devastated the region. The effects of the drought has been felt along the coasts of Senegal and Mauritania across Mali and Niger to the heart of Chad Republic, even into Sudan and Ethiopia. The significant aspects of the incidents of the drought are the crop failures, scarcity of water for drinking, irrigation and watering cattle. The people were forced to migrate across the states and international boundaries on their sourthward journey in search of water and food.

On the global level, the World Health Organisation (WHO) has recognised the urgency of acute water shortage and in its recent 6-year global environmental health promotion programme (1978-83), priority has been given to two major issues - the provision of safe water and sanitation. This is in line with the United National Drinking Water Supply and Sanitation Decade (1980 - 1990).

Wastewater reclamation is becoming an ever more attractive method of increasing the available water resources in order to meet the present and the future needs. This has been the case in Israel where, for example, the conventional water resources are so limited that sewage is being utilized as part of the natural water potential. It has been estimated that about 10% of the total water potential of Israel is sewage water (ref.1).

Direct use of raw wastewater is not generally recommended. The discharge of raw wastewater into water courses may cause massive pollution of the water courses with far-reaching economic and health consequences. However, when adequately treated, sewage effluents may permit repeated uses in a planned way for some beneficial purposes. Treated wastewater are normally returned to water cycle to be used indirectly in diluted forms. In periods of prolonged drought and low flows, the treated effluents may supplement the river flows. Sewage effluents can be used economically and safely in industry as cooling water for towers and boilers at power stations. Cotton textile mills, steel, chemical and pharmaceutical industries may use considerable amount of sewage effluents as cooling waters. Treated sewage effluents can also be put into other uses such as in fish breeding ponds and for irrigation of crops.

The emphasis in this paper is to highlight the potential uses of wastewater as means of boosting agricultural production especially in some parts of Africa where there is widespread drought and where chemical fertilizer is not easily available.

WASTEWATER FOR IRRIGATION

The exploitation of domestic sewage for irrigation is a common practice in some parts of the world especially in countries with insufficient rainfall. But in other countries with adequate rainfall, disposal of sewage by irrigation is practised primarily to protect the water courses against pollution and a secondary effect of slightly increasing the crop yields. In India, for example, it is reported that there are over 132 sewage farms covering approximately 12,000 hectares and utilizing about one million cubic meters of sewage daily (ref. 2). In South Africa and Namibia, it is also reported that about one-half of the released wastewater effluent is used for irrigation and that one-quarter is used for industrial purposes (ref. 3.). Similar operations are practised in Israel, France, U.S.A. etc.

SOME FACTORS AFFECTING THE SUITABILITY OF IRRIGATION WASTEWATER:

Plant Nutrient Value:

The suitability of wastewater for irrigation is based on its considerable fertilizing constituents and soil conditioning values. Besides containing water which maintains proper

moisture levels in the soil, sewage effluent is a valuable source of plants fertilizing nutrients such as nitrogen, phosphorus and potassium. In addition to these manurial values sewage effluent contains a considerable amount of organic matters which when applied to light soils of low humus, can enrich the soil structure by increasing its humus content which may result in significant improvement in crop yields.

Salt Content:

The salt contents of sewage are contributed by such factors as the salt content of original water supply, the rate of water consumption per head and the kind and quantity of salts released into the sewage by local industries and domestic activities. Sewage contains such cations as calcium, magnesium, sodium and anions such as carbonate, bicarbonate, sulphate, chloride and nitrates which are generally essential for plants' growth and which may be toxic to plants only in very high concentrations. Injuries to plants occur as a result of the following identifiable hazards:

Salinity hazard:

Serious salt injury to crops occurs when a high salinity as measured by electrical conductivity or high total dissolved salts wastewater is used for irrigation. In soils which do not transmit irrigation water rapidly enough to keep salts moving downwards through the root zone, salt injury to sensitive crops can occur if wastewater containing more than 1250 ppm dissolved salts (electrical conductivity 2.0μmhos/cm) is applied regularly.

The U.S. Salinity Laboratory has classified the effects of salinity as follows:

Low salinity water (0-250 μmhos/cm)
Moderate salinity water (250-750 μmhos/cm)
Medium to High salinity water (750-2500 μ)

The degree of tolerance to soluble salts varies from plant to plant and is dependent on contact period and the ambient temperature. For example, fruit crops, such as date palm show a high salt tolerance while grape and orange show medium and low salt tolerance respectively.

Sodium hazard:

The quality of an irrigation water depends not only on the total concentrations of soluble salts but also on the relative proportion of sodium (Na^+) to other cations, calcium (Ca^{++}) and magnessium (Mg^{++}). This is usually expressed as Sodium Absorption Ratio(SAR) defined as: (ref. 4)

$$SAR = \frac{Na^+}{\sqrt{\dfrac{Ca^{++} + Mg^{++}}{2}}}$$

where Na^+, Ca^{++} and Mg^{++} are expressed in milliequivalent per liter. The U.S. Salinity Laboratory classified SAR as follows:

Low Sodium water   (SAR 0 - 10)
Medium Sodium water   (SAR 10 - 18)
High Sodium water   (SAR 18 - 26)
Very high Sodium water   (SAR $>$ 26)

Generally, wastewater with SAR $>$15 should be avoided because of the detrimental effect on soil structure and ultimate reduction in the infiltration rate of the soil.

Bicarbonate hazard:

Using "residual sodium carbonate" as a basis of computing for the bicarbonate hazard the U.S. Salinity Laboratory conclude that waters containing "residual bicarbonate" of

1. less than 1.25 meq/1 are proably safe

2. 1.25 - 2.5 meq/1 are marginal   and

3. more than 2.5meq/1 are unsuitable for irrigation.

Boron hazard:

Boron content of irrigation water is of great importance to many crops. Boron in trace quantity is essential for the growth of all plants. However, some crops can tolerate a large quantity of boron while others are very sensitive to it. The crops most sensitive are citrus, nuts and deciduous fruits; semi-tolerant are lettuce, alfalfa, beet, asparagus and date-palms. In general, boron concentration of more than 2.0 mg/1 in irrigation water will seriously affect many crops.

PUBLIC HEALTH AND NUISANCE CONSIDERATION

Wastewater may be generated by municipal industrial and agricultural activities. Because of its nature and origin, wastewater is quite variable in its physical, chemical and biological compositions. Municipal sewage usually contains a full range of pathogenic bacteria, viruses, protozoa and helminths which are excreted in large number by the carriers of a community and which are associated with enteric diseases such as cholera, typhoid, hepatitis and poliomyelitis endemic in the community. Industrial and agricultural wastewater may contain a considerable amount of complex inorganic and organic compounds which may be toxic to plants and animals. Recently, there is an increasing concern about the largely unknown health effects of heavy metals such as mercury and lead which may be present in wastewater.

Conventional wastewater treatment is a well established process for the removal of organic contaminants and pathogens. But while a considerable amount of organic contaminants are removed by the various physical, chemical and biological treatment processes, the bacteria including pathogens and viruses are partially removed.

It is therefore evident that from the public health consideration, the use of raw wastewater is generally not considered desirable for agricultural purposes. Even, the partially treated effluent has to be used with caution.

In addition to the contamination of the crops irrigated with wastewater, there is the potential health risk to the agricultural workers from direct contact with sewage, and the health risks to animals grazing on sewage irrigated pasture. Such direct contamination has been reported in India where there is a high incidence of helminthic infection among the sewage farm population as compared to that of the farming population in general. Sewage irrigation by flooding may encourage the breeding of disease vectors while spray irrigation may result in wide dispersion of pathogens within the aerial sprays. In addition to the microbial and chemical problems associated with sewage irrigation, aesthetic factors such as taste, odour and appearance of sewage water are usually undesirable.

ELIMINATION OF PUBLIC HEALTH HAZARD:

In order to minimize or eliminate possible health risk associated with the wastewater irrigation, the following measures are desirable.

Additional treatment of wastewater effluent:

If wastewater effluent is to be used for unrestricted irrigation of all agricultural crops, a high degree of disinfection is necessary to inactivate the pathogens and viruses. It has been recommended by WHO meeting of experts (ref.5) that crops eaten raw should be irrigated only with biologically treated effluent that has been sufficiently disinfected to achieve a coliform level of not more than 100 organisms per 100ml. in 80% of the samples. Studies by Kott (ref.6) have shown that 20mg/l of chlorine applied to primary effluent for 6 hours achieved a coliform count of not more than 100 per 100ml, while 8mg/l of chlorine achieved the same results in 2 hours when applied to the effluent from a high-rate trickling filter effluent. It was also reported that the treatment was effective in activation of amoebic cysts. Studies by Shuval (ref. 7) have shown that it is quite feasible to achieve a coliform count of around 100/100ml by applying as little as 5mg/l chlorine to the effluent of a high-rate biological filter plant. However, it was shown that with 1-hr contact time, about 10 times as much chlorine is required to achieve the same degree of disinfection for poliovirus as is required for coliforms. Recent Studies by Ogunrombi (ref. 8) shows that a 15 - 25 mg/l of chlorine concentrations applied to Oxigest Plant Effluent for 1 hour consistently inactivate fecal coliform by 99.999%. A higher reduction can be achieved by simply increasing the contact time beyong 1 hour.

There is a trend in many countries to chlorinate wastewater effluents for controlling water-borne diseases. However, wastewater chlorination has become an issue of controversy. There is an increasing concern about the effects of chlorinated-induced toxicity of chlorinated wastewater. A high level of chlorine is usually required to satisfy inorganic constitutents of

wastewater and to maintain an adequate degree of disinfection. Consequently, the residual chlorine may be sufficiently high to have a detrimental effect on aquatic environments. Chlorination of wastewater is further complicated by the possibility of aftergrowth of coliforms and pathogens in chlorinated effluent. Such aftergrowth has been observed by some investigators (refs. 9, 10, 11). When the effluent is to be used for irrigation of food crops, the health hazard of aftergrowth of coliforms and pathogens become apparent. However, in spite of the possible harmful side effects and in spite of the occurrence of aftergrowth, controlled chlorination of sewage effluent is still a desirable process. Disinfection by zone is not widely practised. However, studies by Katzenelson et al (ref. 12) indicate that ozone inactivates viruses many times more rapidly than chlorine. More research is needed in this area.

Restrictive Utilization for certain Crops:

The threat to health associated with wastewater irrigation can be minimized by restricting the effluent irrigation to certain crops not used for human consumption or to crops consumed only after cooking or processing. It is generally considered that only a limited health risk would result from using wastewater effluent for restricted crops. It is usually advisable to restrict the use of wastewater effluent to the following crops:

1. Industrial crops such as cotton

2. Grass grown for hay

3. Vegetable which are only consumed after cooking such as potato

4. Ornamental shrubs, plants and flowers

5. Plants grow for seed

Experiments conducted in India (ref. 13) over a period of 1 - 2 years with essential oil bearing plants citronella and Mentha (Peppermint) as test plants showed that the plants can be grown on sewage and their yield as well as oil percentage are higher than with plain water. Also, the experiments conducted at Ahmadu Bello University, Zaria over a period of 3 years with varieties of barley, maize and wheat as crop tests indicate better grains yield with sewage effluent than with plain water.

SUMMARY AND CONCLUSION

Irrigation with wastewater effluent is widely practised in many countries of the world. Besides containing water, wastewater has manurial and soil conditioning values. Utilization of wastewater effluents for crop irrigation not only aids the agricultural economy but also helps in the control of water pollution. Wastewater irrigation may involve hazards to the soil and a potential health risk to a community. However, with adequate treatment to restore the effluent to high-level quality and with proper management, the health hazards can be minimized or eliminated. The advantages of

wastewater irrigation, nevertheless, out-
weigh the disadvantages particularly in the
light of food production in the more arid
areas where there is widespread droughts.
However, more research is required in order
to identify the full spectrum and concentra-
tions of the chemical and microbial contam-
inants in the waste water effluent, in as
much as they affect the safety or public
health. Also, many psychological problems
remain to be solved to win public acceptance
for the widespread use of wastewater effluent
for irrigation. This is more so in the
arid and semi-arid zones of West Africa
where wastewater irrigation is relatively
unknown. Experimental farms can be
organised to educate both the farmers and
the general public.

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