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in

Hamdy A. (ed.), Monti R. (ed.).
Food security under water scarcity in the Middle East: Problems and solutions

Bari : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 65

2005
pages 291-296

TOWARDS INTEGRATED STRATEGIES FOR POLLUTION CONTROL ON THE USE OF SECONDARY EFFLUENT IN SUSTAINABLE AGRICULTURE

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SUMMARY – Irrigated agriculture will play a dominant role in satisfying the increasing needs for rapidly universal population growth. Using treated wastewater effluent is in a promising resource to bridge the gap between the increasing supply and scarcity of available water resources. However, treated effluent has been successfully applied in many countries; but on the other hand, it should be subject to many major concerns which eventually have adverse impacts on health, crops and soil. Pollution control strategies should be integrated to mitigate the negative hygienic limitations and optimize crop production to achieve the sustainable agriculture and food security under water scarcity.

Keywords: pollution control, wastewater reuse, crop production, sustainable agriculture

1. INTRODUCTION

The current total abstraction of groundwater in Gaza Governorates, which considered the only water resource, is estimated to be 150 MCM/year. The agriculture consumes around two thirds of groundwater pumped through more than 4000 wells located overall Gaza Governorates. The remaining is used for industrial and domestic water supplies. The water balance record reveals a deficit of about 50-60 MCM/year. Reconciliation relies in the strategy of ensuring additional water supply and wastewater reuse schemes. Like arid and semi countries, use of treated wastewater in agriculture is gaining more attention in developing strategies for planning of Palestinian water resources. Irrigated agriculture will pay a noticeable role in the sustainability of crop production to feed the future generations. Secondary and tertiary treated wastewater is increasingly used for irrigation of field crops, orchards and fodder crops in Gaza Strip. However, the use of treated wastewater for irrigation is subject to major concerns because of the potential hygienic and environmental problems. In an effort to reduce non-point source pollution from agricultural lands, planners and farmers should be encouraged to adopt best management and farming practices capable of sustaining the agriculture and reducing chemical, biological and nutrient contamination of groundwater simultaneously.

2. INTEGRTED POLICIES AND STRATIGIES FOR POLLUTION CONTROL

The current pollution control approaches applied in many countries may partially satisfy their ultimate goals besides its constrains especially in the developing countries due to the absence of effective wastewater standards, the lack of law enforcement , lack of awareness and scarcity of funds. An integrated approach as stated in the Palestinian National Water Plan (NWP) which incorporates the needs of the facilitating environment for effective implementation of strategies and the protection and conservation of the water resources balanced against sustainable development of the resource. The elements of the Palestinian water resources stated that the use of wastewater effluent constitutes an important element of overall water resources management in Palestine. In this context, all preventive measures against pollution should be ensured and legal actions against offenders should be taken. A reasonable wastewater reuse policy transforms wastewater from an environmental and health liability to economic and environmentally sound resources (Kandiah, 1994a). So, governments should establish and control wastewater reuse within a wide framework of a national effluent use policy derived from water national water plan. The future strategy is to make the secondary effluent available to farmers for unrestricted irrigation where the pathogens are removed to the maximum extent while the level of nutrients is satisfied. The integrated strategies which introduce the holistic concepts of management, including all the environmental, ecological, traditions predominated, regulatory and institutional framework and the agricultural practices at farm level, beside the lessons learned from others countries are now highly required. Initially and principally, the integrated

strategies start from setting up the necessary legislations and regulations framework to promote and control related activities and to create an institutional set up to enforce the pollution control programs, and protection of water resources to achieve sustainable agriculture which integrates three main goals; environmentally health, economic profitability, and socio-economic aspects.

3. INSTITUTIONAL & REGULATORY FRAMEWORK

The scope and success of any effluent use scheme will depend to a large extent on the administrative skills applied. A stakeholder matrix should be developed to give a clear indication of the different responsibilities and assist in giving an overview of the total water structure in order to avoid any confusion or ambiguity between the concerned authorities. This must define the division of responsibilities among involved ministries and provide for their collaboration. Institutional mechanisms for implementation of the national policy must be established to enforce the related regulations. Furthermore, it includes the development of existing, legislations, creation of new institutions, environmental & agricultural legislation such as standards and codes of practices. Realistic standards must be adopted to safeguard public health and protect against adverse environmental impacts. Such regulations include water quality standards, control measures to reduce human exposure, crop restriction and forcing monitoring systems, violations and penalties. Wastewater quality standards should be adjusted to reflect the local economic and technological level. Effluent standards represent the concentrations of substances which must not be exceeded if a specific use of the water is to be maintained to avoid the adverse impacts of such effluents on soil and crops.

4. USING TREATED WASTEWATER FOR SUSTAINABLE AGRICULTURE

It should be bare in mind that the irrigation nowadays is a multi dimensional process; it has a strongly environmentally sound. Water quality issues have plagued irrigation projects for centuries. Traditionally, irrigation water is grouped into various quality classes in order to guide the user to the potential advantages as wells as problems associated with its use and to achieve optimum crop production to enhance the sustainable agriculture which characterized with its capability of maintaining their productivity and usefulness to society and future generations. Water chemistry problems can impose severe limitations on the use of treated wastewater for irrigation. Treated wastewater used for irrigation purposes has unique characteristics in its physical, chemical and biological composition. Wastewater effluent should be checked for trace element toxicity hazards particularly when trace elements contamination is suspected. The wide use of reclaimed wastewater may create plant toxicity due to high concentration of certain elements like boron and heavy metals.

5. STRATEGIES FOR SUSTAINABLE AGRICULTURE AND PUBLIC HEALTH

The philosophy of World Health Organization (WHO) for safe use of wastewater is the wastewater use guidelines strive to maximize overall public health benefits and the beneficial use of scarce resources (Carr, 2003). However, in order to achieve safe and successful wastewater reuse schemes for irrigation purposes, WHO health guidelines should be integrated with FAO for water quality guidelines used for irrigation purposes. Accordingly there are common multi strategies ultimately combined the optimization of crop production and protecting the human health as summarized hereafter:

- Wastewater treatment level;
- Restriction of the crops grown;
- Irrigation methods; and
- Control human exposure to the waste, and hygiene.

5.1. Treatment

The type of wastewater treatment needed to meet the guidelines is an important issue, taking into consideration the economic constrains. It is necessary that pathogens are removed to the maximum extent (level) possible, while some nutrients to be partially removed. The type of wastewater treatment needed to meet the guidelines is an important issue. However, the cost of treatment to

reach high microbiological standards can be so costly. Therefore, implementation of low cost treatment technology is recommended. Properly designed, adequately implemented wastewater reuse is an environmental protection measure that is superior to discharge treated wastewater to its end use. At minimum, reclaimed effluent must be oxidized and disinfected to minimum standards of secondary treatment. The secondary effluent must be characterized with a 5-day BOD_5 concentration which does not exceed 30 mg/l and has a TSS concentration with 30 mg/l. Ammonia and other nitrogen compounds are additional water quality parameters important in defining the quality of water. Other constituents found in wastewater effluent include metals, organic and inorganic compounds must be considered.

5.2. Crop selection

Crops based on the WHO guidelines can be grouped into three board categories (A,B, and C) with regard to the degree to which health protection measures are required**.** Secondary effluent matches the cultivation of green fodder, olives, peanuts, citrus, bananas, almonds and nuts. However, crop selection should subject to their tolerance to the chemical composition of the treated effluent particularly salinity and boron parameters beside the toxic pollutants to man and plants.

5.3. Irrigation scheduling and techniques

The farmers should be aware how and when to irrigate through practicing the proper irrigation scheduling. The selection of irrigation techniques mainly depend on the quality of the effluent, the crop patterns, and the potential health risks. When using wastewater for irrigation purposes, additional factors such as contamination of plants, harvest products, environment and the salinity and toxicity hazards will be considered (FAO/RENA, 1993a). Proper designed, installed, and managed drip and micro-irrigation systems give higher irrigation efficiency. Several researches have proved the efficiency of subsurface drip irrigation (SDI) application in reducing remarkable pollution o the aquifer when irrigating with treated effluent particularly nitrate leaching due to its unique characteristics in creating proper denitrifcation conditions under the laterals. In addition, SDI systems can ensure highly safety conditions especially in the residential areas.

6. STRATEGIES TO MINIMIZE THE CHEMICAL POLLUTION

6.1. Control of the problem of excessive nitrogen in wastewater

Nitrogen in the irrigation water acts the same as fertilizer nitrogen and excesses will cause problems just as fertilizer excesses cause problems. Therefore, the amount of N and other nutrients applied to the soil with wastewater depends on the amount of irrigation water. In addition, the farmers should calculate the amount of N needed based on the concentration of N in the soil and the quantity of wastewater used. Some crops are highly effective in removing nitrogen from soil, which may eventually move down in the form of NO3-N deeper in soil and contaminate underground water. Grasses such as Sudan grass, Bermuda grass, Sudax, and Rhodes grass remove N efficiently from the soil. These crops are effective in removing nitrates.

Mixing of sewage effluent with fresh water, if available can be used to minimize the adverse effects of excessive nitrogen on health and crop production in specific stages. In relation of excess fertilization, crop development may be adversely affected as indicated in Table 1.

Table 1. Constrains imposed by excess fertilization application levels

Excess	Agronomic Consequences
Nitrogen	Delay in ripening Higher sensitivity to disease Tendency to lodging Burning of seedlings Leaching losses and groundwater pollution
Phosphoric Acid	Poor rate of growth
Potassium	Leaching losses Fixation to the adsorbing complex Increases of soil salinity level Unbalance with magnesium
Magnesium	Toxicity

Source: WSSPs, 2000

6.2. Strategies to minimize salinity, toxic ions and heavy metal risks

The quantity and kind of salts, heavy metals and the nutrients load present in waste water are probably the most important parameters for evaluating the suitability of treated effluent for irrigation. Water amendment can optimize the quality of treated wastewater for irrigation by increasing the calcium level and lowering the alkalinity. High sodium levels in the treated wastewater (high SAR) can reduce water infiltration in the clayey textured soils. By adding dissolved gypsum will increase the calcium level, which can reduce the negative effects of sodium. In addition, the high bicarbonate can be neutralized and maintained pH at a desirable level which leads to improve the soil structure.

Boron is toxic to certain crops at very low concentrations. The greatest toxic effect of boron is found in citrus, deciduous fruits and nuts, at concentrations as low as 0.5 mg/l. Many citrus farms are suffering form excessive boron syndromes particularly lemon trees. The source of boron is usually household detergents and industrial refuses. Several factors like soil texture, soil pH, soil- calcium level, soil organic matter and soil moisture influence boron availability and movement in the soils. However, farmers should cultivate the annual crops and more sensitive fruit trees to mitigate the problem of high concentrations of boron.

Concerning the management aspects of heavy metals, the preferable measures include:

- Liming (use of calcium carbonate).
- Avoid using acid fertilizers.
- Select crops tolerant to certain heavy metals.

6.3. Pesticides

Once a pesticide is in use, it is controlled by safety legislation, a large number of guidance manuals should be issued on the safety precautions to be taken. These manuals usually indicate pollution prevention precautions and include advice on storage, on the disposal of unused material and application. Furthermore, strict regulations may required in abusive or severe illegal usage of pesticides.

7. MONITORING SYSTEMS

Because of the unique characteristics of wastewater, their impact on soils, crops, groundwater and animals, the overall environment should be regularly evaluated and carefully monitored. Monitoring starts by checking the treatment plant for proving its proper functioning through some reliability tests. It will be extends at the farm level. There are several important water quality parameters for irrigation including salinity, SAR, boron, organic materials, and pathogens should be regularly monitored.

Increase in the salt content of wastewater from domestic use, and from private wells must be considered in designing treated wastewater irrigation projects. Strict control must be applied from the wastewater treatment plant, through the conveyance and irrigation systems to the quality of the resulting products, whether they are of commercial or environmental value. In this context, equipping the laboratories with the advanced instruments is prerequisite issue. Pollutants inputs into soil through land application of wastewater may be regulated and monitored through two approaches: One is to prevent toxic chemicals pollutants from accumulating above natural back ground level in the soils. The second one is allowed pollutants to accumulate in the soil as the soil capacity to detoxifying the pollutants to minimum level to humans' agricultural crops and the environmental.

8. PUBLIC AWARENESS

The agricultural sector, particularly farmers will need to be convinced that treated wastewater can provide an attractive resource and they can save money through reducing the fertilizer application, besides resolving out potential problems in implementation. Community participation in all project phases (preparation, implementation, monitoring and evaluation) should be encouraged and ensured as this will lead to the required sustainability. In addition, environmental education programs and public awareness activities should be an integral part of all activities in the management and planning cycle. Concerning the control of human exposure and in relation to the disease transmission, the integration of agro-technical measures like wearing of protective clothing, immunity, and sprinklers or spray irrigation s not recommended under windy or saline effluent characteristics.

9. TRAINING

Lack of skills and knowledge can cause failure in project implementation and, in the case of wastewater reuse projects, can potentially increase environmental and public health risks. Training programs should be integral part of projects, and it should include technical, environmental, health and socio-economic aspects. The educational input must provide the farmers with an understanding of the details of techniques and their associated hazards as well as of the precautions to . However, training the farmers to follow, at least visually or with simple tests, the quality of wastewater could be very helpful. The farmers should be in position to judge whether the wastewater has been appropriately treated. Changes in the colour of wastewater or extensive growth of algae are indicators of chemicals and nutrients in the wastewater at higher levels. Odour indicates insufficient treatment. In this course, it is advisable to train the farmers on using good code of practices which refer basically to the management of wastewater for irrigation, irrigation techniques, nutrient load in he effluent uses and the general guidelines and standards.

10. RESEARCH NEEDS

The main research efforts of this proposal should be oriented towards optimization and safe use of reclaimed effluent to achieve the maximum crop production in order to support food security issues. There is need to further researches deeply focused in minimizing pollution control aspects and improving water quality characteristics simultaneously.

11. TRANSBOUNDERY

In some cases, like the Israeli-Palestinian case, pollution is a transboundary issue and it can cross the political borders causing groundwater and surface contraindication. Common actions like reinforcing the treaties and international or regional environmental regulations are necessary. In this course, The Israeli-Palestinian Joint water committee signed a mutual a memorandum of understanding n sewerage projects criteria and guidelines, stated that the two parties recognize importance of the effective treatment of wastewater for the preservation of water quality and protection of the environment and each side shall take all necessary measures to prevent any ham to other side, water resources or the natural environment from wastewater produced in its territory.

12. CONCLUSIONS

Using treated wastewater for irrigation will minimize clearly the demand on the groundwater and it will reduce the degradation of the environment. The necessary, policy guidelines, legislation and proper institutional set up must be promoted to achieve eventually effective and integrated pollution control strategies to improve the local food security to achieve the sustainable agriculture in a healthy and environmentally sound framework. Furthermore, the agricultural sector, particularly the farmers will need to carry out proper on-farm practices capable of reducing nutrient contamination of groundwater, to maximize the crop production and to avoid the potential adverse impacts on soil, irrigated crops and the ambient environment.

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