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REUSE OF WASTE WATER FOR SUSTAINABLE MANAGEMENT OF WATER RESOURCES

by
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Introduction

Due to population explosion and rapid industrialization, the demand on water resources 'has been increased tremendously. In many arid and semi-arid regions of the world, water has become a limiting factor for agricultural and industrial development. Water resource planners are continually searching for additional sources of water to augment the limited sources available.

When water resources are limited, source substitution is the most suitable alternative to satisfy the less restrictive uses and allowing high quality waters to be used for domestic supply.

Agricultural use of water resources is of great importance because of its abundant use. By the year 2010, further reduction in water resources will take place mainly due to domestic, agricultural and industrial uses. Therefore, there is a need to develop appropriate technologies for development of alternative water resources. One of the appropriate approach to solve the problem of water scarcity is to reuse wastewater.

The reuse of wastewater has become an attractive option for increasing water reserve. The wastewater can be reused for agricultural, industrial, recreational and after treatment potable purposes also. The difference in wastewater irrigation practice in developed and developing countries lies in the fact that in developing countries wastewater irrigation is practiced with raw sewage. The value of wastewater for crop irrigation has been recognized in Pakistan. The sewage irrigation practices in various cities of Pakistan along with other details are shown in table-1.

Types of crops being harvested include; Fodder, sugarcane, cereals, seasonal vegetables and fruits. Indicators, pathogens and parasites present in Lahore sewage are shown in Table-2.

Because of the usage of the raw sewage, fears have been expressed about the possible hazards associated with its reuse: the possible risk to health and potential environmental damage. Health risks are due to pathogenic organisms and toxic materials.

It has been shown in many studies that domestic sewage usually contains the complete range of pathogenic organisms found in the community producing sewage. In one such study (2) various species of pathogenic organisms, such as agents causing typhoid fever, amoebic dysentery, bacillary dysentery, ascaris and other protozoan and helminthic diseases were isolated, from untreated sewage as well as from the effluent of a high rate percolating filter plant (3). Other studies have shown that, the Enteric viruses have been found in raw sewage (1-10 per ml) and in the effluent from conventional treatment plants (4).

Implementing or upgrading agricultural reuse systems

Land application of sewage is an effective water pollution control measure, and a feasible alternative for increasing water resources. The benefits of sewage reuse schemes are economic, environmental and health-related. The use of sewage for irrigation of crops have been substantially increased (5) due to:

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- The increasing scarcity of alternative water resources for irrigation.
- The high cost of fertilizers.
- The assurances that health risks and soil damage are minimal, if the necessary precautions are taken.
- The high costs of advanced wastewater treatment plants needed for discharging effluents to water bodies.
- The socio-cultural acceptance of the practice.
- The recognition by water resources planners of the value of the practice.

Economic benefits can be gained by income generation and by increase in productivity. Substantial increase in income occurred in areas where cropping was previously limited to rainy seasons. A good example of economic recovery due to wastewater irrigation is Mesquital valley in Mexico where agricultural income increased from almost zero to about 16 million Mexican Pesos per ha in 1990 (6). The practice of wastewater fed aquaculture has also been a substantial source of income in many countries such as Bangladesh, India, Indonesia and Peru. The East Calcutta sewage fisheries in India produces 4 -9 T/ha/year of fish (7).

Several studies carried out in various countries have shown that crop yield can increase if sewage irrigation is practiced and properly managed. Table 3 shows the results of increase in crop yields arising from wastewater irrigation in Nagpur, India (8).

Effluents from conventional wastewater treatment plants usually contain Nitrogen (15 mg/l) and phosphorous ((3 mg/l). Such nutrient inputs can reduce or even eliminate the need for commercial fertilizers. The application of sewage provides organic matter that acts as a soil conditioner, thereby increasing the capacity of soil to store water (9).

The following environmental benefits can be gained from the use of wastewater (10):

1. Avoiding the discharge of wastewater into surface waters.
2. Preserving ground water resources in areas where over-use of these resources in agriculture is causing salt intrusion into the aquifers.
3. The possibility of soil conservation by humus build-up and by prevention of land erosion.
4. The aesthetic improvement of urban conditions and recreational activities by means of irrigation and fertilization of green spaces such as gardens, parks and sports facilities.

Policy and Planning

The use of sewage constitutes an important element of water resources policy and strategy. Many countries such as Middle Eastern countries have adopted the use of wastewater as an important component in their overall water resources policy and planning. A judicious sewage use policy transforms wastewater from an environmental and health liability to an economic and environmentally sound resource (11).

To ensure long-term sustainability, adequate attention must be given to the social, Institutional and organizational aspects of wastewater use in agriculture and aquaculture. The planning of sewage use programmes and projects requires a systematic approach. Box 1 gives a

systematic frame work to support the characterization of basic conditions and the identification of possibilities and constraints to guide the planning phase of the project.

Government policy on effluent use in agriculture has a deciding effect on the achievement of control measures through careful selection of sites and the crops that may be irrigated with treated effluent.

The procedures involved in preparing plans for sewage irrigation schemes are similar to those used in most forms of resource planning that is in accordance with the main physical, social arid economic dimensions shown in figure-1. The following factors are likely to have a significant effect on the ultimate success of effluent irrigation schemes:

- The organizational and managerial provisions made to administer the resource to select the effluent use plan and to implement it.
- The importance attached to public health considerations and to the levels of risk taken.
- The choice of single-use or multiple use strategies.
- The criteria adopted in evaluating alternate re-use proposals.

Adopting a multi-use strategy has the advantages of allowing: greater flexibility, increased financial security and efficient use of wastewater throughout the year, whereas a single-use strategy gives rise to seasonal surpluses of effluent for unproductive disposal.

Guidelines for Wastewater Use in Agriculture

WHO has proposed guidelines for the safe use of wastewater to protect public health and environment. The Scientific Group on Health Guidelines for the Use of wastewater in Agriculture and Aquaculture, held in Geneva in 1987 (13) established the basic criteria for health protection of the groups at risk from agricultural reuse systems and recommended the microbiological guidelines given in table 4. These guidelines were the result of a long preparatory process and the epidemiological evidence available at the time. They are related to the category of crops, the reuse conditions, the exposed groups and the suitable sewage treatment systems, in order to achieve microbiological quality.

Conclusions and recommendations

The integration of sewage use planning into national water resource and agricultural planning is very essential due to the following reasons:

- To protect the water sources of high quality water
- To minimize wastewater treatment costs.
- To safeguard public health.
- To obtain maximum agricultural and aqua cultural benefits from the nutrients of wastewater.

The use of sewage has been practiced in many parts of world for centuries especially for agriculture and aquaculture. Many times, the reuse has been performed without any consideration of adequate health safe guards and environmentally sound principles

The Ministries of Health and Agriculture should investigate the current sewage reuse practices and take gradual steps for upgrading health and agronomical practices. This preliminary

survey provides the basis for the clear definition of reuse priorities and the establishment of natural strategies for reuse.

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Table-1
Sewage Irrigation Practices in Various Cities of Pakistan

Cities	Flow mgd	Pollutional load T/BOD/d	Area under cultivation ha	BOD_5 (av) mg/l	%age of sewage being used for irrigation
Karachi	340	443	600	350	44.0
Hyderabad	18	13	100	200	55.0
Multan	45	42	300	250	28.0
Lahore	285	247	800	280	48.0
Faisalabad	50	65	450	350	33.0
Rawalpinidi	48	45	400	250	20.0
Peshwar	21	23	400	300	22.0
Quetta	3	-	20	280	8.0

Source: (1, 2)

Table-2
Indicators, Pathogens and Parasites in Lahore Sewage

Organisms type	Group Name	Units	Average Values*
Indicators	T. Coliforms	MPN/100 ml	1.0×10^9
	F. Coliforms	MPN/100 ml	1.7×10^7
	F. Streptococci	MPN/100 ml	6.2×10^6
	C. Perfringims	MPN/100 ml	7.5×10^4
Pathogens	Salmonella spp	MPN/100 ml	1.0×10^3
	Shigella spp	MPN/100 ml	5.0×10^3
	Pseudamonas spp	MPN/100 ml	4.0×10^3
Parasites	E. Histolytica	No/1-1	90
	A. Lumbricoides	No/1-1	60
	B. Hook worms	No/1-1	40

T=Total; F=Faecal; C=Clostridium; E=Endamoeba
A=Ascaris; *=average of one year data Source: (2)

Table-3
Increases in Crop Yields (tonsha^{-1} a^{-1}) arising from wastewater irrigation in Nagpur, India

Irrigation water	Wheat 8 yrs[1]	Moong beans 5 yrs[1]	Rice 7 yrs[1]	Cotton 3 yrs[1]
Raw wastewater	3.34	0.90	2.97	2.56
Settled wastewater	3.45	0.87	2.94	2.30
Stabilization pond effluent	3.45	0.78	2.98	2.41
Freshwater + NPK	2.70	0.72	2.03	1.70

[1] years of harvest used to calculate average yield Source: Shende, 1985

Table-4
Recommended Microbiological Guidelines for Wastewater Use in Agriculture

Category	Reuse conditions	Exposed group	Intestinal nematodes[1] (no of eggs per litre)[2]	Faecal coliforms (No per 100 ml)[3]	Wastewater treatment expected to achieve microbiological quality
A	Irrigation of crops likely to be eaten uncooked, sports fields, public parks	Workers consumers public	≤1	≤1,000	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent

B	Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees[5]	Workers	≤1	na	Retention in stabilization ponds for 8-10 days or equivalent helminthes and faecal coliform removal
C	Localized irrigation of crops in category B if exposure of worker and public does not occur	**None**	Na	na	Pre-treatment as required by irrigation technology, but no less than primary sedimentation

In specific cases, local epidemiological, socio-cultural and environmental factors should be taken into account, and these guidelines modified accordingly

[4] A more stringent guideline (200 faecal coliforms per 100 ml) is appropriate for public lawns, such as hotel lawns, with which the public may have direct contact.

na Not applicable

[1] Ascaris, Trichuns and hookworms

[2] During the irrigation period. Arithmetic mean

[3] During the irrigation period. Geometric mean

[5] In the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.

Source: WHO, 1989

Box-1 Framework for the analysis of wastewater irrigation project

Nature of the problem

- How much, wastewater will be produced and what will be the seasonal distribution?
- At what places will wastewater be produced?
- What will be the characteristics of wastewater that will be produced?
- What are feasible alternative disposal possibilities?

Legal feasibility

- What uses of wastewater are possible under national and/or state regulation if they exist?
- If no regulations exist, what uses seem feasible under WHO and FAO guidelines or irrigation
- What are the prevailing water rights and how will these be affected by wastewater use?

Technical feasibility

- Is the quality of treated wastewater produced acceptable for restricted or unrestricted irrigation?
- How much land is available or required *for* wastewater irrigation?
- What are the, soil characteristics of land to be irrigated?
- What are the present land use practices? Can these be changed?
- What types of crops can be grown?
- How do crop water requirements match with seasonal availability of wastewater?
- What types of irrigation techniques can be used?
- If groundwater recharge is a consideration, are the hydrogeological characteristics of the study suitable?
- What will be the impact of such recharge on groundwater quality?

- Are there additional health and environmental hazards that should be considered?

Political and social feasibility

- What have been the political reactions to past health and environmental hazard which may have been associated with wastewater reuse?
- What is the publics perception of wastewater reuse?
- What are the attitudes of influential people in areas where wastewater will be reused?
- What are the potential benefits of reuse to the community?
- What are the potential risks?

Economic feasibility

- What are the capital costs?
- What are the operation and maintenance costs?
- What is the economic rate of return?
- What are the cost of development of effluent-irrigated agriculture, e.g. cost of conveyance of wastewater to the irrigation site, and-leveling, installation or Irrigation system, agricultural inputs, etc.?
- What are the benefits from the effluent-irrigated agricultural system?
- What is the benefit-cost ratio for the irrigation project?

Personnel feasibility

- Is adequate local labour and expertise available for adequate operation and maintenance of wastewater treatment; irrigation and groundwater recharge works, agricultural facilities, and health and environmental control aspects?
- If not, what types of training programs should be instituted?

Source: BISWAS 1988

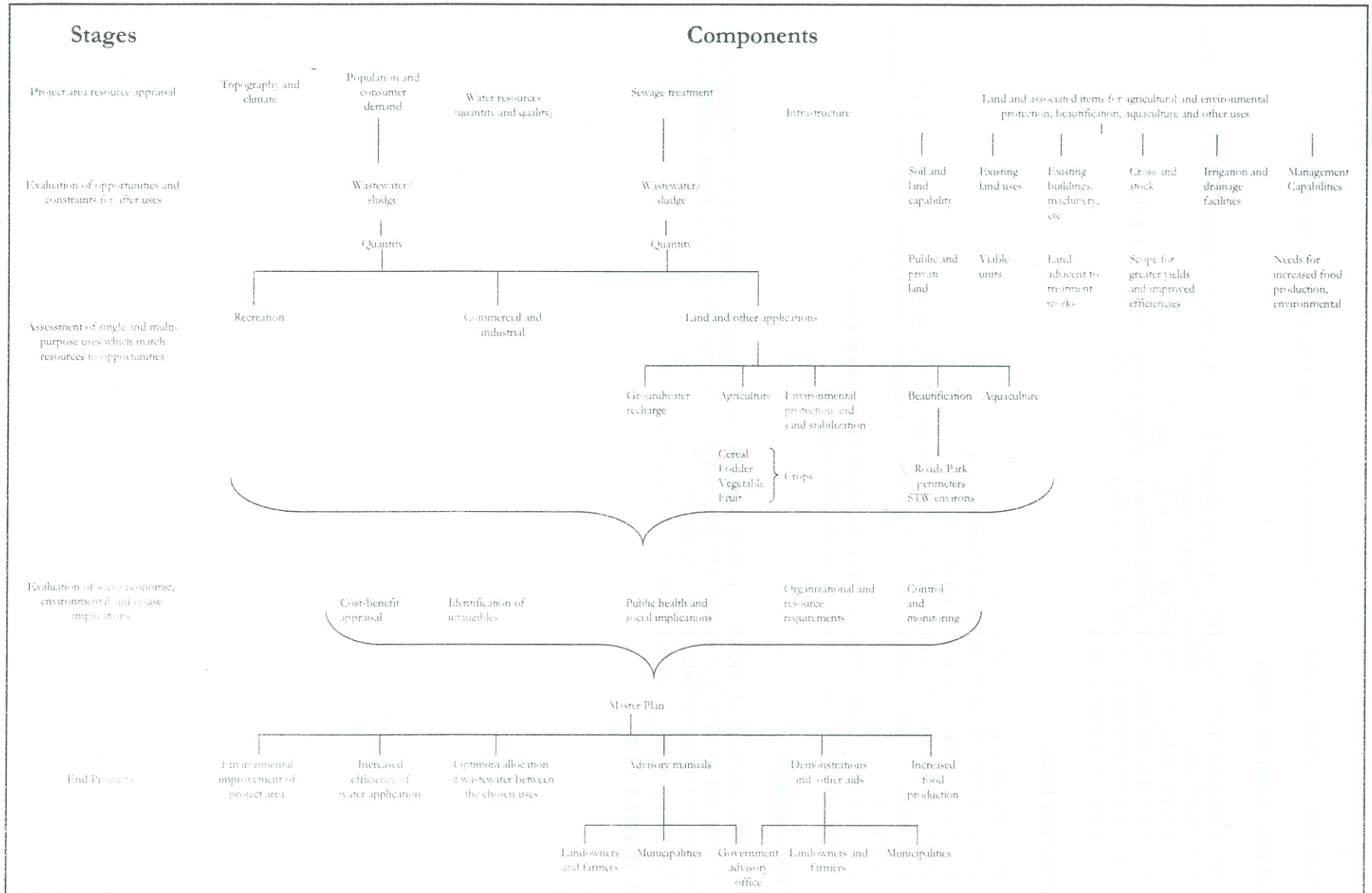


Figure-1: Components of general planning for wastewater use (After Cobham and Johnson, 1986)