ECOLOGICAL RECYCLING OF WASTEWATER FOR URBAN FOOD PRODUCTION

Ms. Arunima Guha
Convenor, Youth Water Forum
W3R 4/7 Phase VII, Golf Green, Kolkata – 700 095, India
Tel : 91 33 9433229588; e-mail : <arunima_g83@rediffmail.com)

1. Introduction

With a booming economy, rapid urbanization and changing lifestyles, cities are producing more waste in Asia. Disposal of waste or drainage water has become a problem in many cities in Asia. Asia had about 202 cities each with one million population in 2000 and some have more than 10 million each. By 2015 out of 26 largest cities 17 will be located in Asia. (UNCHS, 1996). These cities consume large amount of resources and produce waste both liquid and solid. On the other hand millions of people have no access to adequate and safe water and sanitation. Waste must be regarded as resource for sustainable development and not as a disposable matter. Urban system is to become an ecological system in which waste and resource are the same in the same system (Smit, 1996). The conventional system of waste water treatment with extensive network of plants, pumps and pipes is expensive.

Recycling of waste water for aquaculture in wetlands, artificial or constructed, for production of fishes is practiced throughout Asia for a longtime.

2. Ecological Recycling in Wetlands

The urban wetland is a threatened ecosystem. They serve multiple functions including supporting biodiversity of aquatic and plant life, store rainfall and release water into ecosystem. Wastewaterfed wetlands provide food and employment, provide biotic environment for flora, fauna, produces oxygen and a blue and green buffer between the rural and urban areas. Asian cities in monsoon zone and near coastal areas have marshy lands, canals and wetlands. A study in Thailand on the value of wetland says (Choowaew, 2003).

(a) Wetlands can perform a myriad of functions: they recharge and discharge groundwater, control flooding, help stabilize shorelines and prevent erosion, retain sediment and nutrients, export biomass, provide storm protection, water transport, recreation and tourism.
(b) Wetlands can generate products such as forest, wildlife, fishery, forage and agricultural resources, as well as water supplies.
(c) They also possess ecosystem attributes such as biological diversity, natural heritage and cultural uniqueness.

Four aspects may be considered : Productivity, Stability, Sustainability and Equitability.

3. Utilisation of Wastewater

3.1. Aquaculture in Asia

The World Health Organization (WHO) in 1989 suggested reuse of waste water for aquaculture and agriculture rather than expensive wastewater treatment method.

The World Health Organisation has issued guidelines and standards[WHO, 1994] for use of wastewater. According to WHO, the selection of a particular method depends on many factors, including the availability of land, soil type, hydrogeology, financial resources, available technology, quality of wastewater and the quality requirements of any subsequent recovery of the recharged wastewater.

- The recovery is part of a comprehensive urban ecosystem strategy. It can be used for irrigation of roadside plantings, greenery, toilet flushing, industrial reuse including cooling, agriculture development, fishery etc.

Takashi Asano mentions about three main objectives in waste water treatment (a) a watersupply to displace the need for other sources of water (b) a cost effective means for the environmentally sound treatment and disposal of urban waste water, and (c) an incidental secondary benefit from the disposal of wastewater for crop production by irrigation.[Asano, 2000]

Prism in Bangladesh, a nongovernment organisation in Dhaka has developed a highly successful duckweed (Sp. Lemnaceae) cropping system for both domestic waste water treatment and the production of fish protein. Duckweed absorbs almost all chemical substances in the wastewater and treated wastewater is directed into fish production ponds [Ikramullah, 1998].

Haroonabad in Pakistan is using waste water for irrigation for a longtime. The effluent is mainly used to irrigate an area of 120 ha at the main site and an area of 20 ha at two smaller sites despite possible health and environmental risks. The farmers rely on waste water rather than on water from poorly managed canal system. The farmers grow high value short duration crop.[Hassan, 2002].

In 1985 China produced 30,000 tons of fish from sewage waste waterfed fisheries and it is reported that most municipal wastewater in Chinese cities is drained into various water bodies that are used as fish ponds[Zhang, 1990]. Current data is not, however, available.

In Hanoi, Vietnam, the most untreated domestic waste water including sewage effluent (70%) and industrial waste water (30%) is discharged directly into a common sewage and drainage system of 125 km of sewers, 15 lakes, 25 canals and 4 main drainage rivers. Waste water flows in Hanoi by gravity from the city through Thanh Tri district where it has become a valuable resource. The waste water is being used for fish farming, irrigation of vegetables and paddy fields. It produces 3000 tons of fish and 20,000 tons of vegetable each year.[Thang, 1995] There are similar examples from India, Thailand, Cambodia, Indonesia, etc. Patankar of Indian Water Works Association has given some estimates of quantity of waste water supplied to sewage farms in India (mld) and land for farming (ha) in Indian cities such as in Bhopal (16.60 mld and 40.50 ha.). Hyderabad (48.0 mld and 10.85 ha) Varanasi : (82.00 mld and 1020 ha) etc.[Patankar, 2001]. But Kolkata, India has the largest recycling district.

3.2. Kolkata case study

Kolkata (Calcutta) has combined system of sewerage and drainage, besides the liquid waste, there is storm water with heavy rainfall 1200 mm of which 80% occurs within three months with highly irregular distribution. In 1966 the World Health Organisation prepared the Master Plan for watersupply, sewerage and drainage, later Kolkata Metropolitan Development Authority took up some civil works channels. The plan divided metroplitan area into several drainage basins. [Dasgupta, 1991]

Kolkata has the largest recycling of wastewater in the wetland on the eastern fringe of metropolitan area. In 1956-60 the total area of recycling/wetland area was 10,000 ha but due to large scale conversion into paddy cultivation, vegetable fields and urban development total area is now about 2500 ha which is being reduced by encroachment and development. The annual yield of fish product has fallen from 30000 to 15000 tons. The fish ponds known as ‘bherry’ are now only about 150 in numbers.

The underground trunk sewer lines of Kolkata city are linked with 17 pumping stations, all located on the eastern fringes. The trunk drain was designed to take the discharge towards a tidal river on the east.

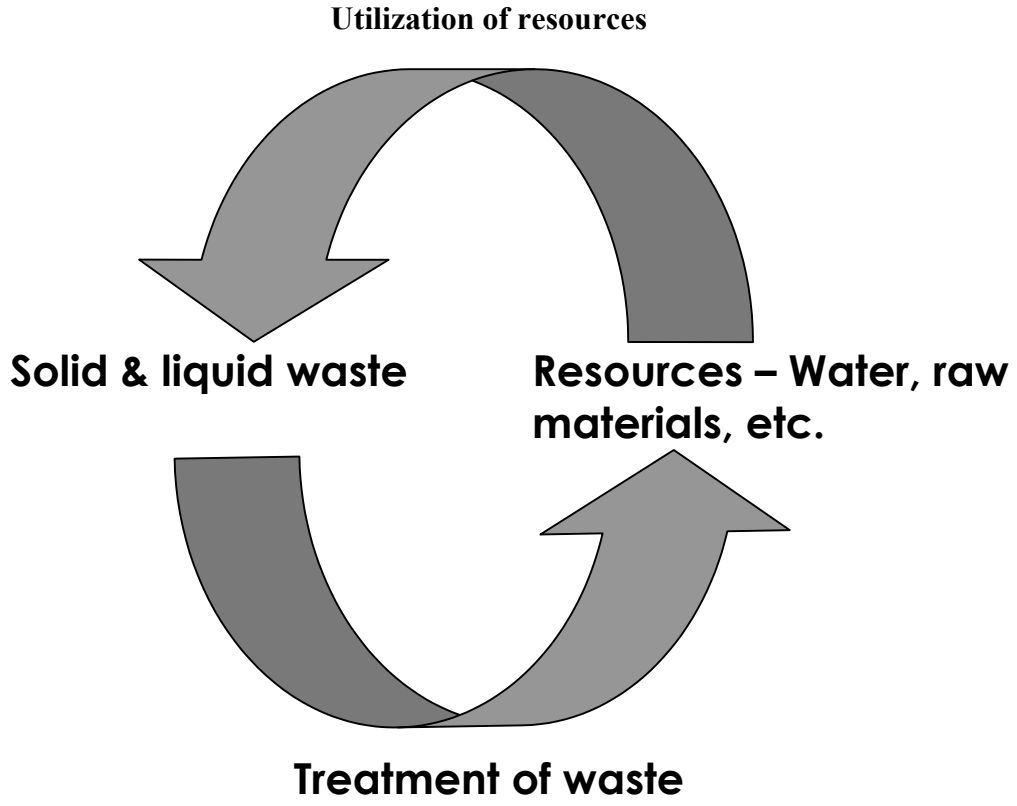

Figure : I Basic principle of wastewater utilisation

The Kolkata municipal system generates about 750 million litres of water daily and 2500 mt of solid waste is disposed on east Kolkata near the wetland. After separating the paper, plastics and metals, the waste is naturally composted. The natural compost is used in the production of good quality vegetables (150 mt/day) without adding any fertiliser but sometimes the nutrient rich sewage fed waste water or sludge is used. The local fishermen were practicing the sewage fed fisheries on wetland for many years. Fish and vegetables meet about 25% of the need of the city.

The pond unit each of lagoon type (between 7 ha – 10 ha in size) is to facilitiate natural aeration through wind action of shallow depth about 1.5 metre to allow sufficient sunlight to reach upto its bottom to promote growth of algae and photosynthetic oxygen is fitted usually with two sluice boxes as inlet and outlet points, for periodical sewage feed exchange from the city's nearest drainage outflow channels and canals. Using aquatic plant like water hyacinth (Eichhornia erassipes) and duckweed (Lamnaceae) water is purified and it is also purified by exposure to sunlight and aeration (oxygenation) enhanced by sun and wind. Oceasional use of lime achieves coagulation and floculation. The State Government declared a Recycling Zone of 12000 ha on the eastern side but this is being threatened by allowing various developments nearby.

In sothewest Kolkata a fishermen's cooperative at Mudialy has taken lease of 15 ponds, 50 ha in area from the Kolkata Port Trust and 23 million litres of waste-sewage water is treated. The area

has been declared as nature park with micro-flora, birds and deers. The recycling of urban drainage process has become an educational centre for children.

The process is advocated in other wastewater discharge areas. It was found that there were hundreds of outfall in the river hooghly (a tributory of the Ganges) in Kolkata and it was found that to reduce pollution under the Ganga (the Ganges) action plan of the Govt. of India it would be very expensive to adopt alternative disposal or treatment. Wetlands, ponds and marshy lands have been brought under the fisheries and the State Government's Fisheries Dept is very active. Three projects in rural fringe of metropolitan area have been taken up with the participation of local people, fishermen and the village council. Community Based Wetland Ecosystem (CBWE) has been first introduced in 1995 in Titagarh, a northern industrial town in metropolitan area.

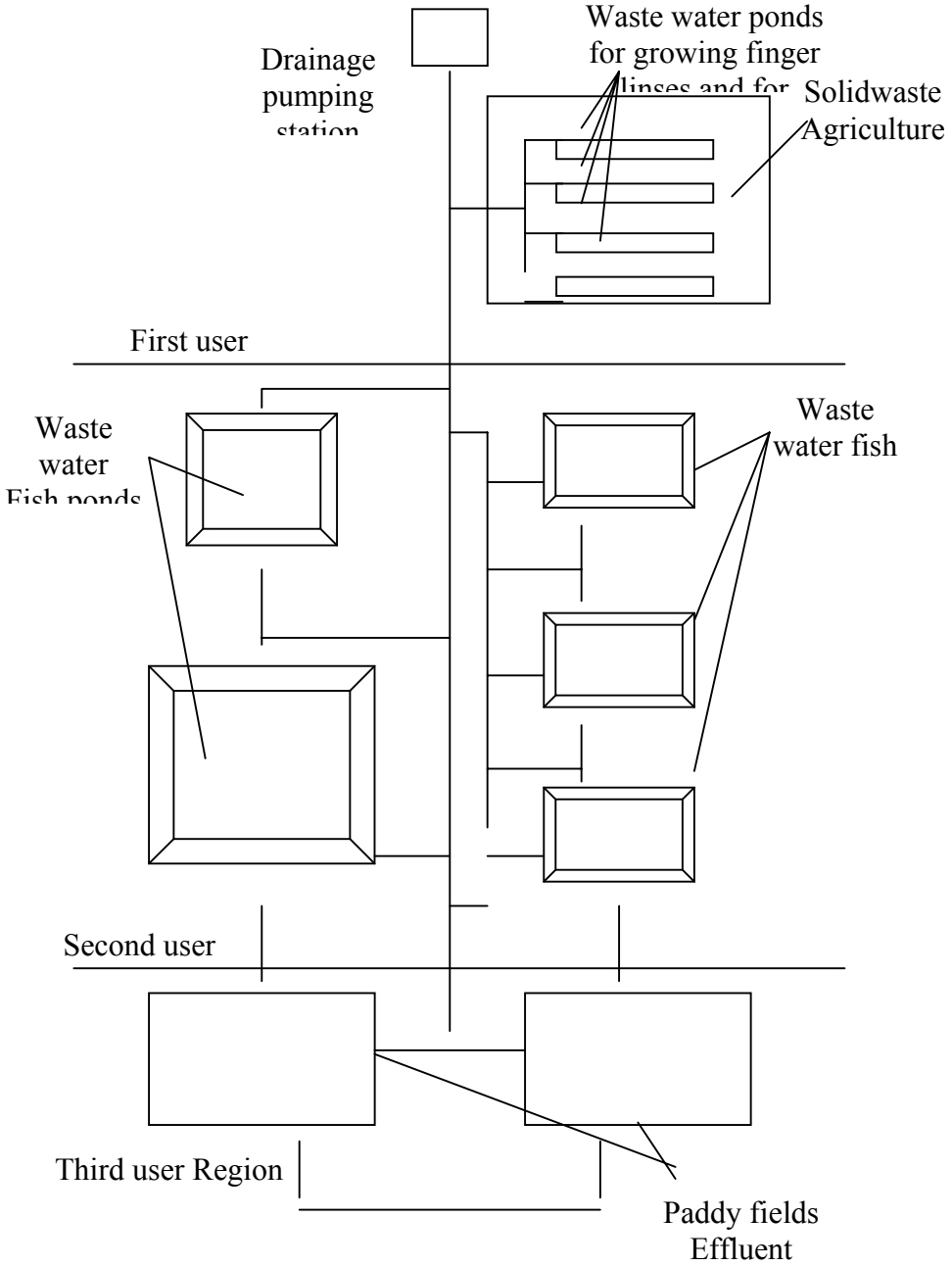

Figure II: Successive Utilisation of Wastewater in Kolkata Wetlands (Source : USAID, 1995)

There are paddy fields in the fringe area of the metropolis and in lower Gangetic area. Traditionally paddy fields require much water and certain species of fish are cultivated but use of chemical fertiliser and pesticides have destroyed the species. Experiments are being carried out to produce fishes in paddy field again with natural process by using wastewater to get multiple benefits.

Figure III : Aquatic Weed to clean water

Figure IV : Fish production

Waste water treatment is the primary objective, but broader aspects of aquaculture, horticulture, livestock and poultry development, agroforestry etc. are required as buffer between the urban and rural areas to prevent sprawl. Industrial employment has declined in many cities and growth of informal sector employment in aquaculture and agriculture in the wetlands in and around cities is to be encouraged.

The high productivity of these fish ponds is mainly due to rich nutrient element in waste water like nitrogen, phosphorous, potash, calcium etc and the high alkanity stimulates production in the fish food chain. There are several parameters. It generates abundant quantity of algael photosynthetic oxygen at the assured rate of 1 gm algae synthesized to produce about 1.25 gm of oxygen and thus dissolved oxygen is found to be 0 mg/l at the inlet point to 16.20 mg/l at the outlet zone. The biochemical oxygen demand (BOD), a critical parameter of waste water quality is 150-180 mg/l at the inlet to about 15-32 mg/l at the outlet. Chatterjee calculates that wetlands in east Kolkata releases 226.75 kg oxygen/day/ha.[Chatterjee, 1999] Health and hygiene aspects of fish and segetables have been found satisfactory.

A basic manual prepared by USAID advocates integrated wetland system. The wetlands or natural depressions act as waterbodies to receive city's wastewater can be utilised like these in Kolkata through sustainable technology for wastewater treatment and resource recovery and advantages are : [USAID, 1995].

(a) Reduced consumption of conventional energy
(b) A flexible system
(c) More efficient removal of coliforms
(d) Encouraging food scarcity
(e) Contributes to rural development
(f) Institutionalizes participation of the stakeholders
(g) Longer life span of the treatment facility
(h) Minimum construction

The recycling of urban drainage system for productive reuse is yet to be integrated in the landuse plan for the cities. There are also health aspects with monitoring and control. Further research is required for institutional aspects. Education, training and public awareness are also essential.

There are several lesions learnt from Kolkata examples

(a) Wastewater can be a part of overall water resource plan especially in cities. It has many benefits, one of them is to replace fresh water supply for irrigation, aquaculture, industrial water use, landscape gardening, horticulture etc.
(b) Instead of expensive wastewater treatment measures, indigenous technology can purify the waste water, with exposure to sunlight and use of aquatic plants.
(c) Sewagefed wastewater can be utilized by recycle for production of fish and such water can be used with sludge and natural compost for production of vegetables. Increasingly such practice is being used in many countries in Asia, Africa and Latin America.
(d) It provides employment and poor farmers and fishermen can organize themselves into cooperative society and it can be a best practice with multiple stakeholders.
(e) It improves environment with more oxygen and controls pollution.
(f) It is cost effective process. It eliminates transport, marketing and other costs.
(g) It can be a tool of good land management, creates a buffer zone of green and blue between urban and rural areas and leads to sustainable development.
(h) Health and hygiene aspects will be a lesson after necessary regulation, control and standards.

4. Wetlands Livelihood Options

The wetlands with productive ecosystem can provide food mostly in developing countries. More and more cities in India, China, Vietnam, Bangladesh and other countries are practicing aquaculture for production of fishes and edible aquatic plants and using wetland water and sludge for vegetable production in nearby or surrounding areas. Stephanie Buchler et al (Buechler, 2002) of IWMI advocates developing typologies of waste water use for the purpose of standardizing categories as there are also health related aspects. Wetlands have high potential for food production.

It is estimated that about 2.4 million people in Bengal (Indian part) are presently dependent on wetland products for their subsistence (Ghosh, Dr. S, 2004). There are more than 380 wetland plants and more than 44 species are important as food and vegetables. Traditional commercial practices include indigenous building materials, aquatic plant for ornamental handicraft, mats, nuts, water chestnut, lotus, aquarium plant, supplementary vegetables are medicinal herbs.

5. Impact of Climate Change

Asia has a large coast line and urbanisation has taken place on the coastal side in many countries and such areas are in low land with wetlands, estuaries and marshy areas. Due to unsustainable pattern of development many of the wetlands have been filled up or encroached and livelihood of poor people depending on such wetlands have suffered. The recent economic boom in Asian countries are causing ecological doom as the wetlands are part of ecosystem. There is high risk of climate change in low elevation coastal zones. Large areas are likely to be florded. There will be salt water intrusion affecting agri-aquaculture. Climatic hazards are evident in flooding and drought, wetland which have shallow depth are damaged, either because of flooding or because of evaporation. The impact of climatic change on the ecosystem of wetlands is yet to be studied.

6. Conclusion

Wastewater recycling should be part of integrated water resource management plan "Reduce, recycle and reuse" is one of the environment policies to be adopted and the waste must be regarded as resource for sustainable development. Often indigenous treatment of urban drainage is better than chemical mechanical treatment and disposal. The agri-horti-aqua-culture in the periphery of cities has multiple benefits providing employment, nutrition and food security, better environment, land and water management etc, with green and blue landscape creating an ecological balance and a buffer between the urban and rural areas. [Ghosh, 2007]

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References

Asano, Takashi . Waste water management and reuse in megacities. In Juha Uitto and Asit K Biswas, (eds) 'Water for Urban areas, challenges and prospective'. United Nations University Press, Tokyo, 2000.

Buechler, Stephanie et al. 'Waste watr use in urban agriculture' in Urban Agriculture Megazine, No. 8 December, 2002.

Chatterjee Sivabrata. Wetland preservation and its importance for Calcutta. In Wetland and urban Environment Report, Centre for Urban Economic Studies, Calcutta University, Calcutta, 1999.

Choowaew, Dr. Sansanee. Sustainable Wetlands Development, Mohidol University, Bangkok, 2003.

Dasgupta, Subir. Drainage of the Calcutta Area : An overview in Biplab Dusgupta, et al, eds 'Calcutta's 'Urban Future' Calcutta, Govt. of West Bengal, 1991.

Edwards, Peter. Reuse of human waste in Aquaculture. UNDP-the World Bank, Washington DC, 1992.

Ghosh, Santosh. Indigenous Technology in urban waste water management and food production. Paper at International Congress on Wastewater treatment for Small Communities, Sevilla, Spain, 2007.

Ghosh Dr. S.. Traditional Commercial Practices in Sustainable Development and Conservation in Wetlands. A paper at 3rd IUCN World Conservation Congress, Bangkok, November, 2004.

Hassan, Mehmood Ul. Maximizing private and social gains of waste water agriculture in Haroonabed in *Urban Agriculture Magagine*, no. 7, August, 2002.

Ikramullah, M. Lamnaceae based waste water treatment, Dhaka. Prism, Bangledsh, Dhanmondi, Dhaka, 1995.

Patankar, Sn. Use of treated wastewater – a study of agriculture, in India, case study, Paper Asian at workshop on wastewater reuse management. ICID Congress, September 2001. Seoul, 2001.

Smit, Jac. et al. Urban Agriculture, Foods, Job and Sustainable Cities, UNDP, New York, 1996.

Thang, Van Quet et al. Some Public Health, Aspects of Sewage Utilisation for fish farming and irrigation in Hanoi, Vietnam, IDRC Research project. Paper at International workshop on urban Agriculture, December 1995. Centre for Built Environment, Kolkata.

UNCHS, Habitat. An Urbanising World : Global Report on Human settlements. Oxford, Oxford University Press, Oxford, UK, 1996.

USAID. Integrated wetland system (IWS) for Wastewater Treatment and Recycling, for the poorer parts of the World with ample sunshine. Basic Manual, USAID, Arlington, Virginia, USA, 1995.

WHO (World Health Organisation). Guidelines and standards for the use of wastewater. WHO, Geneva, 1994.

Zhang ZS. Wasterwater fed fish culture in China. In P Edwards and RSV Pullian (eds), Waste water for Aquaculture. Asian Institute of Technology, Bangkok, 1990.