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Open Access **Short Review**

Application on Reuse of Wastewater to Enhance Irrigation Purposes

Anupam Khajuria

Department of Mechanical and Environmental Informatics, Tokyo Institute of Technology, Tokyo, Japan

Corresponding Author: khajuriaanu@gmail.com

Abstract:
Water resource management has become a challenge in developing countries as the infrastructural development has not kept pace with population growth and urbanization. Even though India is endowed with a network of rivers, the level of water resource availability is still insufficient to meet national demand. With the issues of water scarcity, the wastewater reuse is one of the important methods to save water resource. In the present work, we have discussed the critical issues and opportunities of reusing the wastewater, which helps to overcome the demand of water supply. We have also suggested the recommendations and policy implementations for safe consumption of wastewater reuse in irrigation and various purposes. This article shows the importance of wastewater utilization, and the new and innovative technology and policies which encourage the use of wastewater as a new or reuse resource. The reusing wastewater address the problem of water scarcity and other environmental problems, which reflect the need of environment assessment and able to achieve sustainable management of wastewater.

Keywords: Water resources, Wastewater, Reuse, Management, Water scarcity, Irrigation, India

1.0 Introduction:
Continuing population growth, rapid industrialization, and expanding and intensifying food production are all putting pressure on water resource which causes a significant increase of wastewater (Corcoran et al., 2010). The uncontrolled disposal of the municipal, industrial and agricultural waste constitutes one of the most serious threats to the sustainability by contaminating the water, land and air pollution (Bogner et al., 2007). There are many challenges that developing countries facing i.e., lack of necessary infrastructure such as electricity, roads and water supply, etc. On the list of priorities, wastewater drainage, sanitation and treatment tend to rank higher (Corcoran et al., 2010). According to the United Nations World Water Development Report (2006), "providing the water needed to feed a growing population and balancing this with all the other demands on water, is one of the great challenges of this century". Wastewater can be defined as the flow of used water discharged from homes, industries, commercial activities and institutions. In other words, the wastewater is defined as a combination of domestic effluent consisting of black water (excreta, urine and faecal sludge) and grey water (kitchen and bathing wastewater), water from commercial establishments and institutions, including hospitals, industrial effluent, storm water and other urban runoff, agricultural, horticultural and aquaculture effluent, either dissolved or as suspended matter (Corcoran et al., 2010; Bagher et al., 2013). Here, we exclude the industrial chemical effluent that can be potentially harmful and must be treated separately. The great challenges in removing the different types of wastes from water are diverse. The intent of a more sustainable wastewater management system is to use less energy (or possibly produce energy), allow for the elimination or beneficial reuse of bio-solids, and restore natural nutrient cycles (Daigger and Crawford, 2005). Wastewater is a secondary water resource, especially for water shortage countries (Bogner et al., 2007). However, the water tables and aquifers are declining (Nilsson et al., 2005; Khajuria et al., 2013).

India is predominantly an agricultural country with 65-70 percent of the population depends on agriculture (CGWB, 2011). Irrigation is drawn from rivers or other natural water bodies. By 2025, demand for domestic and industrial water usage may increase and water availability for irrigation is expected to reduce (Singh, 2004). In metro cities, only 24% of wastewater is treated from households and industries (Mekala et al., 2008). However, an estimated 80% of wastewater generated by developing countries, especially India and China, is used for irrigation (Winrock International India, 2007). It is an urgent need of effective water resource management through enhanced water use efficiency and wastewater reuse with effective treatment. There is a necessary need of an innovative technology which helps to reduce the energy demand of wastewater and policies to reduce the negative impact of wastewater and encourage the use of wastewater as a new resource.

In order to tackle the problem of water resource management, it is necessary to first develop a better understanding and discuss the challenges and opportunities of converting urban wastewater into a managed natural new water resource for irrigation and other purposes. In addition, we have also discussed adequate policy recommendations for managing wastewater effectively, especially in case of India.

2.0 Significance of Wastewater Reuse:

Wastewater reuse is not a new concept, although recently, it is receiving a great importance because of the global water crisis. The wastewater reuse may be evaluated through the comparison of wastewater reuse potential with total water use. Generally, wastewater reuse is small compared with total water, but it is expected to increase significantly (Corcoran et al., 2010). Wastewater reuse can be used for many purposes, including agricultural irrigation, industrial processes, firefighting, aquaculture, domestic use, wetland creation and aquifer recharge (Bogner et al., 2007). In many parts of the world, such as in the United States, Australia and Japan, treated wastewater has been successfully used for various purposes (Crook and Surampalli, 2005; Hamilton et al., 2005). In Japan, wastewater reuse is mainly directed toward non-potable urban applications such as toilet flushing, urban environmental water and industrial reuse (Lu and Leung, 2003).

The potential of wastewater reuse depends on the hydraulic and biochemical characteristics of wastewater, which determine the methods and degree of treatment required. While irrigation generally requires a lower quality of treatment of wastewater (Angelakis and Bontoux, 2001). In China, for example, at least 1.33 million hectares of agricultural land are irrigated with untreated or partially treated wastewater from cities. Irrigation has the advantage of "closing-the-loop" combination of waste disposal and water supply (Glen, 2008). Irrigation reuse of wastewater could be the application for agricultural crop and landscape areas. The reuse is conventional and economically viable, particular in agricultural purposes as shown in **Figure 1**. For instance, the use of reuse wastewater for irrigation of tea-tree plantations, which produce tea-tree oil as a cash crop and eucalyptus forestry is a major resource option followed in Australia (Vigneswaran et al., 2004). The use of wastewater in agriculture is a best possible strategy for addressing water scarcity and nutrient deficiency in agricultural systems in the face of climate change (Kanyoka and Eshtawi, 2012).

3.0 Use of Wastewater for Irrigation: Case of India:

In many parts of India, wastewater is disposed into rivers and the contaminated river water is used for irrigation. The growing cities cannot handle the sewage produced and it is disposed into water bodies. More than 80 percent of wastewater is discharged into natural waste resource without any treatment because of lack of infrastructure and resources for treatment (Corcoran et al., 2010). The huge amount of wastewater is produced, whereas only one-third amount is collected and less than that amount of wastewater is treated with the reference of the database of aquastat of year 1998-2002 and 2002-2012 as shown in **Figure 2**. The untreated urban wastewater is used downstream for uncontrolled and unrestricted irrigation. The increasing scarcity of alternative waters for irrigation, high cost of artificial fertilizers and advanced treatment plants, sociocultural acceptance of the practice and the demonstration that health risks and soil damage is minimal if necessary precautions are taken (Blumenthal, 2000).

The wastewater reuse can make a significant difference in peri-urban agriculture, which has evolved to become very important for urban food supply. The potential irrigated land from available municipal waste is estimated 1.1 million hectares (Amerasinghe et al., 2013). However, there is no comprehensive estimates of total agricultural area are using wastewater irrigation. The wastewater irrigation in peri-urban farms can be direct or indirect: direct when sewage is used for a sewage channel close to/adjacent to the field and indirect when sewage flows into a water body and water is taken from this polluted water bodies. A variety of crops are grown through wastewater such as rice, wheat, fruits, flowers and fodder/grasses, and the unique case of the East Kolkata wetlands, fish farming in wetlands. Thousands of livelihoods are supported by such agriculture (IWMED, 2004), however, a continuous quality monitoring of treated water would be required (Starkl et al., 2015).

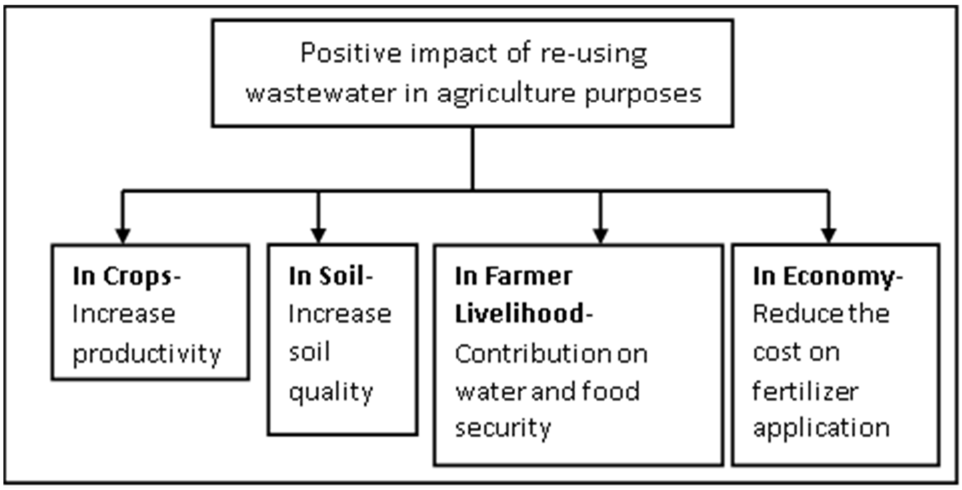

Figure 1: Positive impact of reuse of wastewater, particular in agricultural purposes

The wastewater has increased over the years as demand has grown and the water is used from different sources such as wastewater generation, however, the treatment capacities are vary between cities, and the current treatment capacities have been increasing significantly like Hyderabad and Ahmedabad cities (Amerasinghe et al., 2013). Gujarat is one state which has shown how sewage management can benefit agriculture called “Smart option”. It reduced the use of groundwater in agriculture, ensured the management of sewage, improved yield and earned financial support. In the Gandhinagar city of Gujarat, wastewater is carried in a 22-km long underground pipeline from which farmers extract water and the irrigation department of the state tracks the use and charges farmers for it. However, the sewage supplied to farmers is not treated properly (Down To Earth, 2015). In another point of view, the wastewater irrigation is an issue of concern for public agencies responsible for maintaining environmental quality and public health (Qadir et al., 2010). Taking the step to improve the use of wastewater, a start-up policy document from the government have started which emphasizing the water conservation and reuse and recycle the wastewater for utilizing the various purposes.

3.1 Wastewater Irrigation Risk on Agricultural Land:

Wastewater is a reliable water supply for crop production (cereals and vegetables) in areas where freshwater is scarce. However, the wastewater irrigation poses several threats to agricultural land. The effluent discharge is high metals which can retard the crop growth. Nitrogen is used through fertilizers, which is beneficial for the crop under the limited amount. The wastewater is higher in salts, can affect plants either through causing osmotic stress or via direct toxicity. The leaching of soils below the root zone may cause soil and groundwater pollution. Wastewater irrigation may lead to transport of heavy metals to fertile soils, affecting soil flora and fauna and may result in crop productivity. High nutrient content usually found in wastewater helps to reduce input costs and it provides an ideal medium, e.g., for aquaculture, can replenish groundwater reserves and in this way the economic value of municipal wastewater could be gradually recognized (Schmoll et al., 2006; Khajuria et al., 2014).

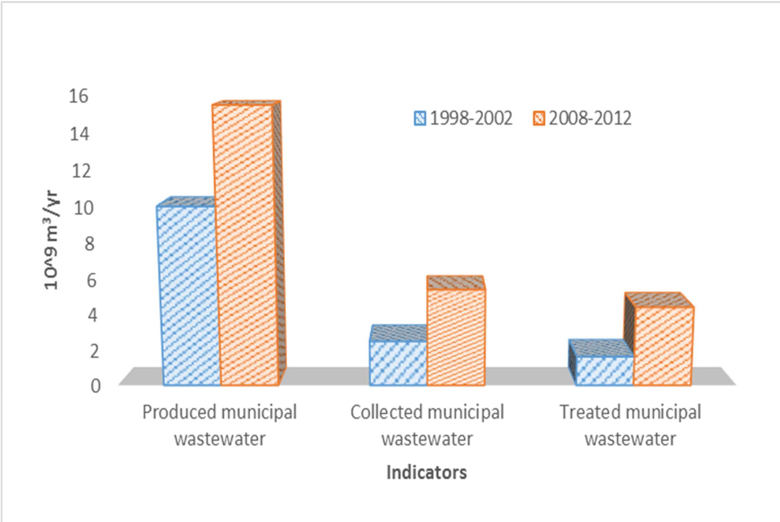

Figure 2: Percentage of municipal wastewater (Production-Collected-Treated) in India

Source: Data from Aquastat (1998-2012)

http://www.fao.org/nr/water/aquastat/data/query/results.html

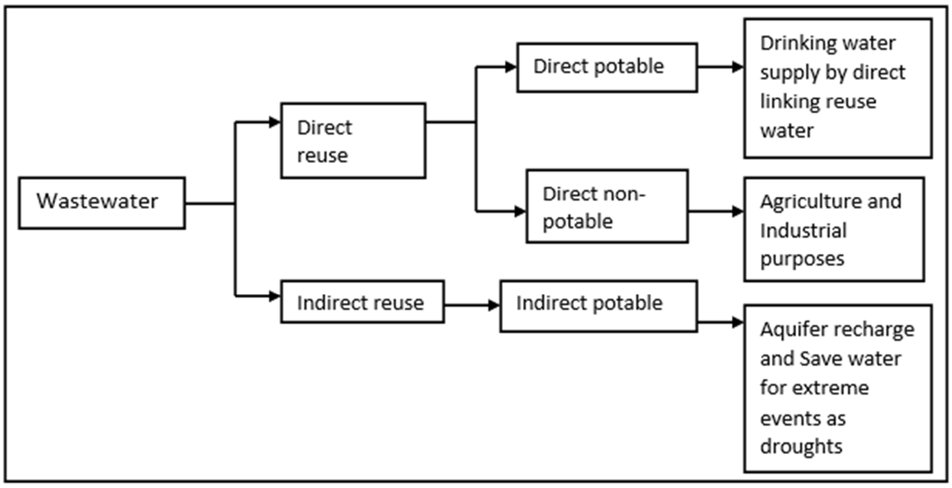

Figure 3: Applications on reuse of wastewater

The wastewater irrigation may have long-term economic impacts on the soil, which in turn may affect market prices and land values of saline and waterlogged soils (Hussain et al., 2002). The actual impact of groundwater involved the depth of water table and quality of groundwater. According to an IGES report in 2000, 20 million hectares of land in 50 countries was being irrigated with raw or partially treated wastewater. This is almost 10 percent of the total irrigated land in the world. Countries such as Vietnam, Kuwait, Israel, Tunisia, Jordan, Morocco and China extensively use wastewater for irrigation. Vietnam produces 80 percent of its vegetables using wastewater (Down To Earth, 2015). The proper perspective of reusing wastewater for economic planning should be viewing the reuse as a part of the best solution of efficient water resource management.

3.2 Wastewater Irrigation Risk on Human Health:

Wastewater irrigation poses a number of risks to human health, could be direct or indirect, manifesting as short/long term illness. The more specific risk is pathogenic microorganism including bacteria, viruses and worms. The prevalence of diarrheal diseases and hookworm infection was very high in farmers working in wastewater irrigated fields, while in children of these farmers the prevalence of these diseases was also high. Besides farmers and their families, there is an indication that crop consumers might have a higher chance to acquire an infection with hookworm (Feenstra et al., 2000). The high concentration of nitrate causes methemoglobinemia, commonly known as 'Blue Baby syndrome' (Amerasinghe et al., 2013).

4.0 Policies and Economic Opportunities to Reduce Risk of Wastewater Irrigation:

An estimated 80 percent of the sewage generated in the developing countries is discharged untreated into the environment, and half of the population is exposed to polluted water sources (UNESCO, 2003). Policies are needed to reduce the risks and to optimize the wastewater management. Policies to reduce the negative effect of wastewater use while supporting the other benefits. The primary task for farmers is to boost their productivity with the rich nutrient use of wastewater and increase their net returns in agriculture. Introduce new and innovative policies influence the cost of managing the wastewater. Effluent standards and taxes can be used to improve the wastewater management from small scale firms and companies. Policies and institutional framework could be helpful to raise the funds for encouraging the water saving and reuse of wastewater. Maintain and investment in the wastewater treatment plants and programs to optimize the use of wastewater for various purposes.

Pursuit of prudent strategies for water management will be more active if we recognize the resource potential of wastewater, which is a powerful opportunity for sustainable economic development and growth (Corcoran et al., 2010). Wastewater treatment is a desirable process for mitigating the hazards of agricultural, industrial, and municipal by-products. The economic valuation indicators will be used to identify the value of direct and indirect use of wastewater, which is directly related to cost and benefit in the agricultural purposes. The cost-benefit analysis follows the direct /indirect aspects- wastewater effluent, agricultural practice, crop productivity, policies and institutions and socio-economic conditions, which helps to optimize the direct and direct cost of wastewater reuse in agriculture.

However, investors are wary to finance water infrastructure projects demanding high upfront costs and long development periods (Hsueh-min Patrick Hung, 2015). The cost of wastewater treatment plant can be divided into investment and operational maintenance cost with the public funds. To implement the reuse wastewater program, the effluent should be treated to a quality acceptable to the end user and agriculture purposes. The cost-benefit relationship in the reuse of wastewater shows that the public and private investment could be both economically and socially beneficial.

5.0 Recommendations

1) Adopt multi-sectoral approach to wastewater management- The multi-sectoral approach could be beneficial for as a closed loop of nutrients and enhance the potential of wastewater for reuse in irrigation, or to generate biogas, turning the nutrients into resources.
2) Merge the public and private sector at the local and national level- The framework of policies could involve the local authorities and communities to fulfil the need and capacity of the local communities.
3) Forward thinking and innovative planning- The forward thinking and innovative planning of local communities could contribute to the challenges of water scarcity to enable the adoption and increase the opportunities of solutions of wastewater problems.
4) Treatment solutions must be economically and environmentally- Wastewater treatment technology should be low-cost, with an important approach of planning and development to incremental of long term success. With the emerging of new technologies, the scarcity of water and changing perceptions of wastewater may emerge as a valuable and beneficial resource.
5) Develop and implement of wastewater treatment plants- The wastewater treatment system helps to remove organic, inorganic and biological pollution without reducing the content of organic matter in the water. These plants must be inexpensive, eco-friendly techniques and follows the cost-benefit approach between the use of wastewater and consumer.
6) Socio-economic benefit- To develop and introduce new policies which protect the environment and human health have to adapt an wastewater treatment and management approach, facilitate the government and public participation.

6.0 Conclusion:

In conclusion, we have found that the growing population has dramatically increased the urban wastewater in developing countries, such as in India. With the issues of climate change, increases in urban population and increases water demand, the reuse of wastewater has emerged as an important and alternative option to continuously depleting freshwater supplies as shown in **Figure 3**. With the emerging technologies, the scarcity of fresh water and changing perceptions, wastewater may emerge as a valuable resource. The technology must involve recycling/reuse of fertilizer, which helps to reduce the excessive nutrient load in irrigated land and increase the agricultural productivity. The wastewater used for irrigation requires less treatment and its best methods for irrigation in a water scarce area. The reuse of wastewater decreases the money spent on fertilizers and the treated water is considered as safe and clean, since it has been properly treated. Proper consideration of the health risks and environmental quality restrictions must be an important and integral part of the wastewater treatment. The effective and efficient wastewater technologies and management confer the significant co-benefit for sustainable development in both waste and water management sector. The reuse of wastewater for agricultural purpose can help to mitigate the problem of water stress, food security and treatment of wastewater rural and urban areas. Water recycling and reuse is meant to help close the water cycle and therefore enable sustainable reuse of available water resources, addressing the water security issues. Thus, our study can be utilized to attain success and sustainable management of wastewater as effective quality, which can contribute to the challenges of water scarcity.

***Note:** This work is not related with UN work and system. *Present Affiliation: Researcher, United Nations Centre for Regional Development, Nagoya, Japan*

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