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Potential Use of Municipal Wastewater for Agriculture: A Case Study from Anuradhapura

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ABSTRACT

Effective harvesting and diverting of domestic and industrial wastewater to the agricultural lands contribute to escalate the food production in achieving the present world's food demand. This study was conducted to examine the potential use of wastewater generated in Anuradhapura municipal area for Agriculture. A questionnaire survey was conducted as primary data source and secondary data were collected from National Water Supply and Drainage Board and Department of Census and Statistics. The questionnaire survey was carried out using a randomly selected sample of 100 city dwellers and industries. Secondary data was verified using the questionnaire survey. Results revealed that per capita water consumption in the city was 153 liters /day which is not significantly different ($p>0.05$) from the secondary data with the National Water Supply and Drainage Board (147 liters /day). Wastewater generation in the city was 1,940,533m^3/year (60% of water consumption) and the domestic wastewater production was 1,226,467m^3/year (70% of domestic water usage). Above half of studied population was effectively used wastewater for home gardening while majority were preferred to use wastewater for agriculture. Regarding the industrial wastewater generation, about 33% of commercial firms in the city were treating wastewater before releasing into the environment while others just directed their wastewater in to drainage system. Therefore, it can be concluded that, wastewater collection in Anuradhapura city do not properly functioning since the sewer system has not well established. More than 3.6 million liters of generated wastewater left daily without reuse which can be effectively utilized to enhance the small scale agricultural activities together with decent treatment methods and collecting system.

Keywords: *Agriculture, Anuradhapura city, Treatment, Wastewater*

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1. Introduction

The rapid industrialization, urbanization, agricultural activities in many countries resulted generation of large quantities of waste materials, which may be adversely affect on healthy environment. Wastewater can be categorized as black water, grey water, and storm water. Most of the times grey water and storm water let drain into a water sink in near proximity without any treatment (Jayakody *et al*., 2006) which eventually cause environmental problems such as eutrophication of natural water bodies. Many larger countries like China and India are using more than 80% of wastewater for agriculture (Amerasinghe *et al*., 2013). In the other hand, most of the countries facing issues related to water quality problems due to lack of wastewater treatment (Amarasinghe *et al*., 2013). Wastewater is widely used as an alternative to conventional irrigation water, even untreated, particularly when water for irrigation is in short supply (Van der Hoek, 2004).In Sri Lanka, wastewater agriculture is practiced in very few localities most of which are informal usages with domestic wastewater for home gardens.

A previous study was conducted to examine the potential usage of wastewater for paddy cultivation in Puttalam district, of Sri Lanka (Udagedara and Najim, 2009) and concluded that about 22% of uncultivated paddy fields in Maha season and 5% of uncultivated paddy fields in Yala season can be brought under cultivation with the efficient collection and utilization of gray water. Hence, there might have a good potential for reuse wastewater for agriculture in Anuradhapura district, since majority of dry zone paddy production is extended around the Anuradhapura district. The wastewater generated in Anuradhapura city is not highly polluted compared to highly urbanized areas like Colombo, since the number of industries present is lesser. Therefore, this study was conducted to assess the generation of domestic and municipal wastewater in Anuradhapura municipal area and to examine the potential use of generated wastewater for agriculture. The main objective of this research was to study the potential of using domestic and municipal wastewater for agriculture while assessing the volume of domestic and municipal wastewater generation in Anuradhapura municipal area.

2. Methodology

This research was conducted in Anuradhapura municipal area which is located in the north central province of Sri Lanka. The urban population in Anuradhapura is 48913 (Department of census and statistics, 2011). City elevation is 81m and well built irrigation and tank cascade system is one of the land marks of this area. Irrigation canals are spread all over the area which supply water to nearby fields. The city is not highly industrialized. Only one large apparel factory and a few rice processing plants are established in the area.

A questionnaire survey was conducted using a randomly selected 77 dwellers and 23 industries in the Anuradhapura municipal area during March 2014 to May 2014 as a primary data source. Secondary data were collected through existing data bases from Department of Census and Statistic (DOCS) and National Water Supply and Drainage Board (NWSDB) to gather information about population, city water consumption, existing and proposed city sewer systems and their maintenance procedures, water purification methods in Anuradhapura city. The data from NWSDB were used to determine per capita water consumption and the DOCS data were used to determine mean house population. The accuracy of the secondary data was confirmed with the questionnaire survey and data was analyzed using Microsoft office Excel. Certain parameters of wastewater generation such as domestic water consumption per day, reusable wastewater volume etc. were determined using collected data from questionnaire survey as average water consumption per month , average monthly water consumption per person and average daily water consumption per person. SAS® software was used to verify the primary and secondary data with analysis of variance (ANOVA) at 5% probability level.

Per capita consumption of water (70% of domestic water usage) and whole city water consumption (60% of water consumption) were determined based on the international accepted figures for wastewater return flows (SLSI, 2003).

3. Results and Discussion

Municipal Wastewater in Anuradhapura City

The main sources of industrial wastewater generated in the Anuradhapura city were hotels, vehicle cleaning service stations and the teaching hospital. Most of them consisted with wastewater treatment plants but the condition and operational level were not optimum. Anuradhapura teaching hospital was the main hot spot in the city which was producing highly polluted wastewater among the aforementioned wastewater generated sources. Untreated and partially treated hospital wastewater was discharged to the near drainage canals since the wastewater treatment system was not working properly (Jayakody *et al.,* 2006). The records from the DOCS and the NWSDB in Anuradhapura revealed that the water consumption in the whole area was 3,234,222 m^3. Above half (1,752,096 m^3) was consumed by domestic people through 8,361 domestic water connections. Furthermore, per capita water consumption in the city was 147 liters /day. However, according to the results of our study, per capita daily water consumption in Anuradhapura city was 153.2 liters /day. There were no any significant difference ($p>0.05$) between the per capita daily water consumption data obtained from questionnaire survey (153.2 liters) and the secondary data from DOCS and NWSDB (147 liters). The average number of members per household in Anuradhapura city was 4.32.

Wastewater Treatment

Almost all of the domestic users and 67% of industrial respondents were not owned any wastewater treatment method and generated wastewater was discharged in to sewer systems or drainage canals. Some of these canals were directed that water into *Malwathu oya* or near fields. According to the results of questionnaire survey, 13 % of the domestic respondents were interested on establishing a treatment plant at their homes and they were preferred to spend money for the water treatments. Due to lack of initial capital, majority (87%) were not willing to bare an extra cost for wastewater treatment (Figure 1). However, approximately 33% of industrial owners have treated wastewater before discharge and they also agreed to spend money for establishing new wastewater treatment plant since the low performance of the existing plants (Figure 2).

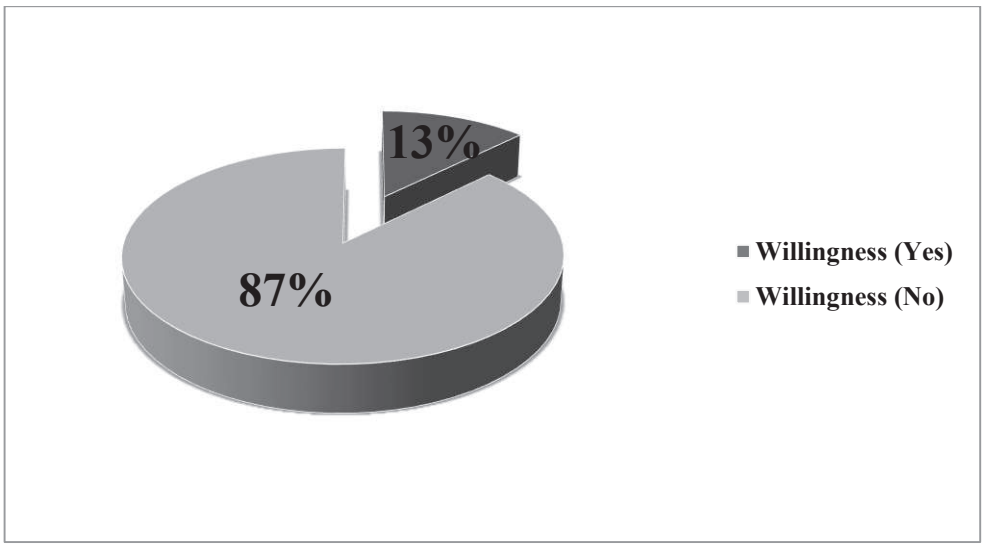

Figure 1; Willingness of domestic respondants on wastewater treatmnet

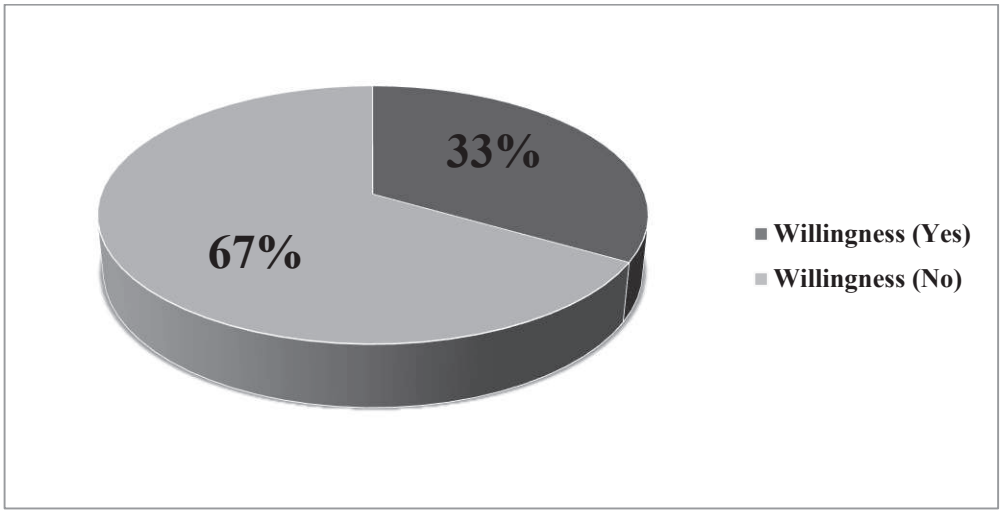

Figure 2; Willingness of industrial owners on wastewater treatmnet

Wastewater for Agriculture

The questionnaire results revealed that above 51% of domestic users utilized wastewater for agriculture at small scale home gardening. Others discharged wastewater in to the drainage canals, sewer systems and barren grounds (Figure 3).

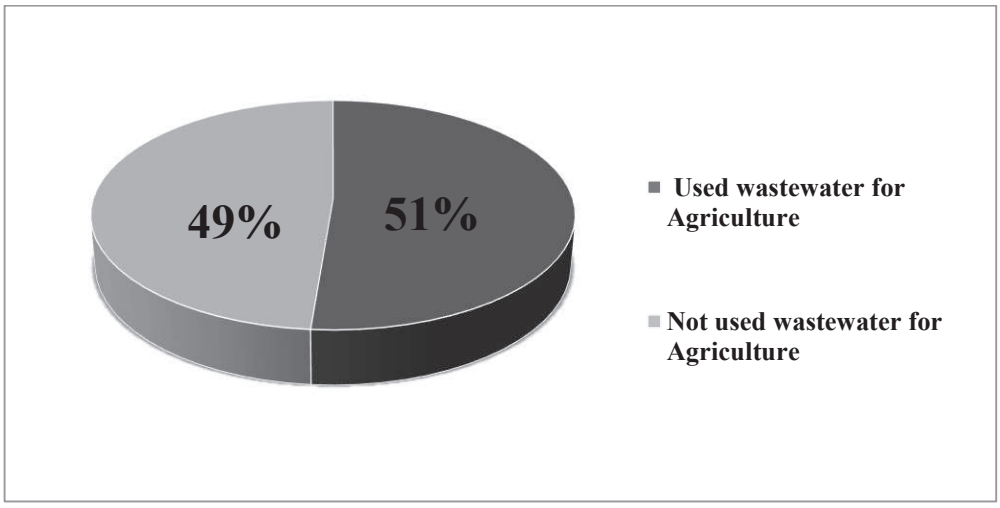

Figure 3; Usage of wastewater for agriculture

City Sewer System

The sewer collection and management system which maintained by Anuradhapura municipal council covered only about 10% of the city. Therefore, only 20% of respondents showed good attitude towards city sewer system while others suffered due to unavailability of sewer system (Figure 4).

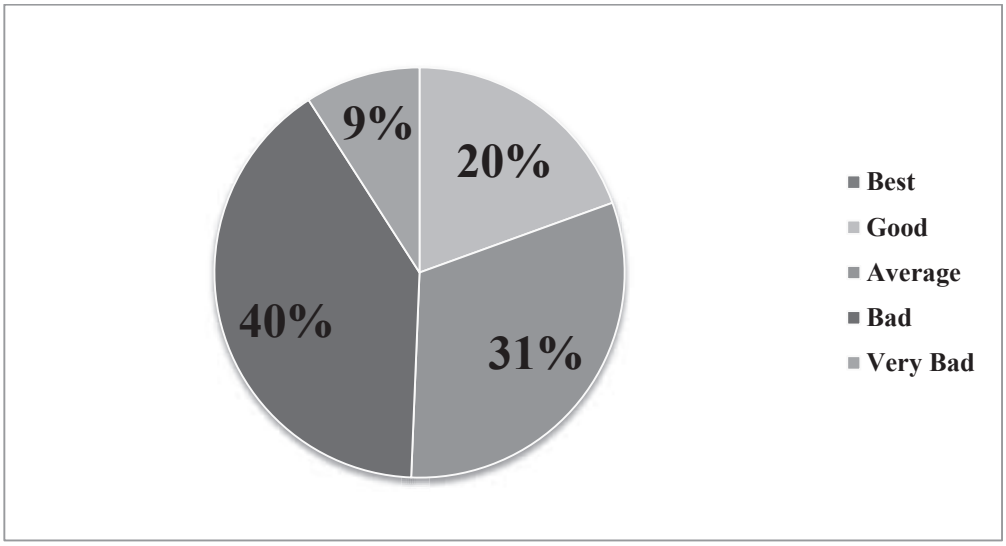

Figure 4; Response on the city sewer system

Wastewater Generation and Reusable Volume in Anuradhapura City

Wastewater generation of a city is governed by many factors. According to city officials, as a rule of thumb, nearly about 60% of the water supply to the city ends up in the canals as wastewater, though there can be variations in this amount according to geographical location of cities, climate, and people's behavior, level of industrialization etc (Jayakody *et al.,* 2006). By assuming a consumptive use of water as 20-40% for urban use in general and among them average 70% of urban water returns as waste. About 70% return of domestic water consumption is an internationally accepted figure for wastewater return flows (SLSI, 2003). The wastewater generation and the domestic wastewater production in Anuradhapura city were 1,940,533m^3/year and 1,226,467m^3/year respectively.

We have found that approximately 50% of domestic users utilized wastewater for home gardening while remaining domestic and almost all commercial and industrial wastewater might have discharged into natural environment without recycling. Therefore, the amount of reusable wastewater produced can be estimated as 1,327,299.6 m^3/year. There may have good potential to use 3.6 million liters of daily generated reusable wastewater in the city for the agriculture especially for paddy cultivation since the Sri Lankan paddy production is mainly centralized in North Central Province. It has found that 8 to 11 mm/day of water is transpired from a low land rice field and water requirement for 1 ha rice field is about 100m^3 /day (considering 10mm water loss per day) (Imbulana *et al.,* 2006). Generalizing those figures with results of the present study, 36 ha of paddy fields can be cultivated per season using that amount of wastewater generated within the Anuradhapura city. However, certain infrastructure and socio- economic factors should be further developed to achieve above target.

4. Conclusion

The utilization of waste water for agriculture is practiced in very few localities in Sri Lanka. Among them, Anuradhapura city showed a good potential for wastewater agriculture since the largest extent of paddy production is distributed around the district. The results revealed that the above half of studied domestic population was effectively used wastewater for agriculture while majority were preferred to use wastewater for agriculture. The results show that about 30% of commercial firms in the city were treating wastewater before releasing into the environment. Since the sewer system is not well established, wastewater collection in Anuradhapura city does not function properly. Hence , it can be concluded that more than 3.6 million liters of wastewater left without reuse daily in Anuradhapura city which can be effectively utilized to enhance the small scale agricultural activities together with proper wastewater collecting and treatment system.

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