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Wastewater Use in Agriculture- A Case Study in Periurban Area of Mymensingh District

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Abstract

Wastewater (ww) is important for the farmers of developing countries for the production of field crops and short rotation plantations (SRPs) during the shortage of irrigation water. Wastewater is rich in nitrogen, phosphorus, zinc and other heavy metals. In principle ww can be easily diverted to farmers filed with a very low cost. Other important matter is the appropriate selection of SRPs for the supply of firewood to farmers and the SRP will reduce the deforestation rate in the country by supplying biomass for firewood. Recently the authors conducted field works in some municipalities to know the peoples interest for ww and SRPs use in Bangladesh. This study reveals that during the period from November to May, there is an acute shortage of water and ww will be the only source of water to use in crop cultivation and SRPs production in Bangladesh.

Keywords: Wastewater discharge, Short rotation plantation, Waterhyacinth, Nutrients

1. Introduction

Fresh water is only 0.003 percent of the total water available in the world. Therefore, there is always a great need of maintaining water supply free from pollution and other detrimental activities to safeguard men, animal and plant kingdom. The whole fresh water may be contaminated if optimum protection measure is not taken at right time. Technology should be developed to reuse water after use and transformation into "waste". That means, wastewater can be made usable by making its sufficient storage facility, treatment facility and proper reuse technique for domestic, agricultural and forest wood production systems.

Wastewater reuse has not yet started in a greater way in Bangladesh. Only a part of the wastewater is currently used and almost more than 90 % is diverted to nearby canal, river or ponds. It is usually believed that diverting the wastewater into the natural places is usual and this water cannot create abnormalities in water system but for the past few years, fishes in the natural water bodies are dying and no prevention measure is being taken either by government level or private sectors. Some people are using wastewater without any treatment for vegetable production. In Mymensingh periurban areas, wastewater is used for the production of paddy, horticultural crops, raintrees and vegetables. This wastewater contains high level of nitrogen and phosphorus thus increases soil fertility and lowers dependence on chemical fertilisation in crop production. Normally this water is used in vegetable cultivation: cauliflower, cabbage and radish and fish cultivation in a ditch but because of its content of potential pathogens and heavy metals the reuse of untreated wastewater cannot be recommended for any kind of agricultural food production. This increases its reuse potential for non-food biomass like wood fuels.

If wastewater could be stored, treated and then reused, the problem of pollution resulting from untreated wastewater can be solved and stopped. This water can be reused for agriculture and forest culture for biomass production. Shortage of fire wood can be met up and this will help growing afforestation in the country.

Hillman (1988) has drawn attention to the particular concern attached to the cumulative poisons, principally heavy metals, and carcinogens, mainly organic chemicals. World Health Organization guidelines for drinking water quality (WHO 1984) include limit values for the organic and toxic substances. Shuval (1985) reported on one of the earliest evidences connecting agricultural wastewater reuse with the occurrence of disease.

The physical and mechanical properties of the soil are very sensitive to the type of exchangeable ions present in irrigation water. Dissolved salts increase the osmotic potential of soil water and an increase in osmotic pressure of the soil solution increases the amount of energy which plants must expend to take up water from the soil. As a result, respiration is increased and the growth and yield of most plants decline progressively as osmotic pressure increases. Although most plants respond to salinity as a function

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of the total osmotic potential of soil water, some plants are susceptible to specific ion toxicity.

Morishita (1985) has reported that irrigation with nitrogen-enriched polluted water can supply a considerable excess of nutrient nitrogen to growing rice plants and can result in a significant yield loss of rice through lodging, failure to ripen and increased susceptibility to pests and diseases as a result of over-luxuriant growth. He further reported that non- polluted soil, having around 0.4 and 0.5 ppm cadmium, may produce about 0.08 ppm Cd in brown rice, while only a little increase upto 0.82, 1.25 or 2.1 ppm of soil Cd has the potential to produce heavily polluted brown rice with 1.0 ppm Cd. Therefore, important quality parameters include a number of specific properties of water that are relevant in relation to the yield and quality crops, maintenance of soil productivity and protection of environment. Absolute purification of wastewater is not always possible. Some type of short rotation plants can be considered to grow instead valued crops. These plants will supply firewood for the people and biomass for alternate energy production for the rural poor.

Environmental issues associated with wastewater use are the main subjects of a UNEP (1991) document. On the basis of the above discussion the following objectives were set to study the current use practice wastewater in the periurban areas of Mymensingh municipality in Bangladesh.

The main objectives of this study are to collect the field level information on wastewater utilization and its prospect in Bangladesh. The specific objectives are:

1. Study on wastewater related parameters
2. Wastewater treatment and influence of wastewater use in irrigation

2. Methodology

2.1 pH

pH may be defined as the negative value of the logarithm of the hydrogen ion concentration (strictly speaking hydronium ion concentration), i.e.

$$pH = -log_{10}[H^+] = log_{10}\frac{1}{[H^+]} \qquad (1)$$

The normal pH range for irrigation water is from 6.5 to 8.4; pH values outside this range are a good warning that the water is abnormal in quality. Normally, pH is a routine measurement in irrigation water quality assessment. A digital pH meter (Milwaukee Smart pH system SM100, accuracy at (25^{0}C) range ±0.2 pH) uses an electrode to measure the pH of a solution. Before taking a pH measurement, the meter must be "calibrated".

2.2 Electrical Conductivity (EC)

Electric Conductivity is defined as the ability of a substance to conduct an electric current and it is the reciprocal of electrical resistivity. The unit of measurement commonly used is the Siemens/cm (S/cm), microSiemens/cm (μS/cm), or milli-Siemens (mS/cm). In aqueous solutions conductivity is directly proportional to the concentration of dissolved solids, therefore the higher the concentrations of solids, the greater the conductivity. The relation between conductivity and dissolved solids is expressed, depending on the application, with a good approximation, by:
1.4 S/cm = 1 ppm or 2μS/cm = 1 ppm (part per million of $CaC0_3$)

Where,
1 ppm = 1 mg/L is the measuring unit for dissolved solids

In addition to conductivity meters, there are TDS instruments that automatically convert the conductivity value into ppm, thus providing a direct reading of the dissolved solids concentration. DiST 3 (HI 98303, range 1999 μS/cm) was used in the field experiment.

2.3 Total Dissolved Solids (TDS)

TDS is a common measurement of freshwater. When TDS is determined by summing the results of separate analyses for all major ions, it is analogous to salinity. When TDS is measured gravimetrically (by weight), it can be greater or less than salinity, depending on whether loss of bicarbonate (H_2CO_3) in the gravimetric analysis is more than offset by the presence and, consequently, measurement of dissolved organic carbon. A gravimetric measurement of TDS in water in an alkaline media would probably indicate lower TDS than if TDS were measured by summation or salinity because not enough organic matter would be present in the water to make up the H_2CO_3 weight loss. DiST 2 (HI 98302, range 10.00 ppt (g/L)) was used in the field experiment.

2.4 Test kids for onfarm analysis

The concentration of NH_4^+, NO_2^-, NO_3^- and PO_4^{3-} are measured semi-quantitatively by visual comparison of the reaction zone of the strip with the fields of a colour scale. The sample material may be wastewater, soils, fertilizers and food. A wide range of colorimetric and titrimetric rapid testes and ion-specific Merckoquant® test strips are available for the determination of many other ions and compounds.

3. Results and Discussions

3.1 pH

Sample of wastewater was collected from the Beltoli, Chorar Beel, Vatera and Maskanda area from January 2005 to November 2005 (Table 1), whose mean values were 6.21, 5.3975, 4.6539 and 4.5018 respectively. During rainy season volume of wastewater increased. As a result pH value also increased. It means wastewater is less acidic. pH value increases due to the formation of some unknown organic acids and neutralizes during the passage through the channel, rainfall and absorption by plants, soil surface, crops and fishes and some bacteria.

3.2 EC

The average EC values were 1099.4545 µs/cm, 989.8788 µs/cm, 704.0909 µs/cm and 609.3636 µs/cm at Maskanda, Vatera, Chorar Beel and Beltoli areas respectively (Table 1). Various factors which affect EC are industrial or hospital waste, rainfall, solid waste, wastewater volume in the channel, natural treatment by waterhyacinth. Waterhyacinth and other small plants absorbed heavy metals from wastewater and neutralized unknown organic acids. At Maskanda area wastewater contains more salts; as a result EC values were the higher than those of other areas.

3.3 TDS

The mean values of TDS were 0.4545 ppt, 0.4482 ppt, 0.3000 ppt and 0.1489 ppt at Maskanda, Vatera, Chorar Beel and Beltoli areas respectively (Table 1). There may be many factors such as hospital and clinical waste, solid waste, rainfall, waterhyacinth, volume of wastewater in channel, etc which influence the amount of TDS in the wastewater. During rainy season TDS decreased due to high dilution of wastewater but in the dry season it increased due to higher concentration.

3.4 NH_4

The highest NH_4 value was found in Maskanda area and it was 70 mg/l. NH_4 in the area of Vatera, Chorar Beel, Beltoli were 20.9 mg/l, 7.4 mg/l and 0.00 mg/l respectively (Table1). Waterhyacinth, duckweeds, grass, crops, etc absorbs NH_4 which helps to decrease NH_4 in wastewater. Rainfall also dilutes NH_4 in the wastewater.

3.5 PO_4

PO_4 values at different places were measured. The highest value was obtained at Vatera and the lowest value was obtained at Beltoli (Table 1).

Table1: wastewater parameters at different areas in 2005

Area		pH	EC, *µs/cm*	TDS, *ppt*	NH_4, *mg/l*	PO_4, *mg/l*
Maskanda	Mean	4.50	1099.45	0.45	70	57.27
	STD	0.67	139.81	0.10	52.38	57.19
	STD error	0.12	24.34	0.02	9.11	9.95
	CV(%)	14.98	12.72	23.04	74.84	99.86
Vatera	Mean	4.65	989.88	0.45	20.90	111.63
	STD	0.88	31.75	0.08	24.17	88.41
	STD error	0.15	5.53	0.01	4.20	15.39
	CV(%)	19.03	3.21	17.02	115.60	79.20
Beltoli	Mean	6.21	609.36	0.15	0.0	0.0
	STD	0.37	12.62	0.02	0.0	0.0
	STD error	0.06	2.20	0.003	0.0	0.0
	CV(%)	6.01	2.07	12.96	-	-
Chorar Beel	Mean	5.40	704.09	0.30	7.45	85.54
	STD	0.62	28.56	0.05	6.70	27.30
	STD error	0.11	4.97	0.00	1.16	4.75
	CV(%)	11.52	4.06	17.57	89.93	31.91

3.6 Wastewater treatment facility

There is no wastewater treatment facility available in the survey area but wastewater is being purified or naturally treated during the passage through the waterhyacinth, grass, duckweeds, crops, small plants etc (Fig.1).

Fig.1 Wastewater treatment using waterhyacinth

3.7 Effect of wastewater on Soil

Survey carried out at different locations surrounding Maskanda, Vatera, Beltoli and Chorar Beel. Farmers and farm labors were questioned and the following results were observed: 88% farmers responded that wastewater increases soil contamination by sedimentation of sludge, nutrients etc. on soil, 94% opined that wastewater is good for crop production because less chemical fertilizer is required, free of cost, wastewater is available throughout the year etc., 93% reported that wastewater adds fertilizer, 91% responded that wastewater increases acidity which causes low yield and only 2% reported that wastewater could not be useable for production of rice or crops etc.

3.8 Irrigation with wastewater

Expansion of urban population, increased coverage of domestic water supply and sewerage are the main causes of greater quantities of municipal wastewater (Fig.2). With the current emphasis on environmental health and water pollution issues, there is an increasing awareness of the need to dispose this wastewater safely and beneficially. Use of wastewater in agriculture could be an important consideration when its disposal is being planned in arid and semi-arid regions. However, it should be realized that the quantity of wastewater available in most countries would account for only a small fraction of the total irrigation water requirements. Nevertheless, wastewater use will result in the conservation of higher quality water and its use for purposes other than irrigation.

As the marginal cost of alternative supplies of good quality water will usually be higher in water-short areas, it makes good sense to incorporate agricultural reuse into water resources and land use planning.

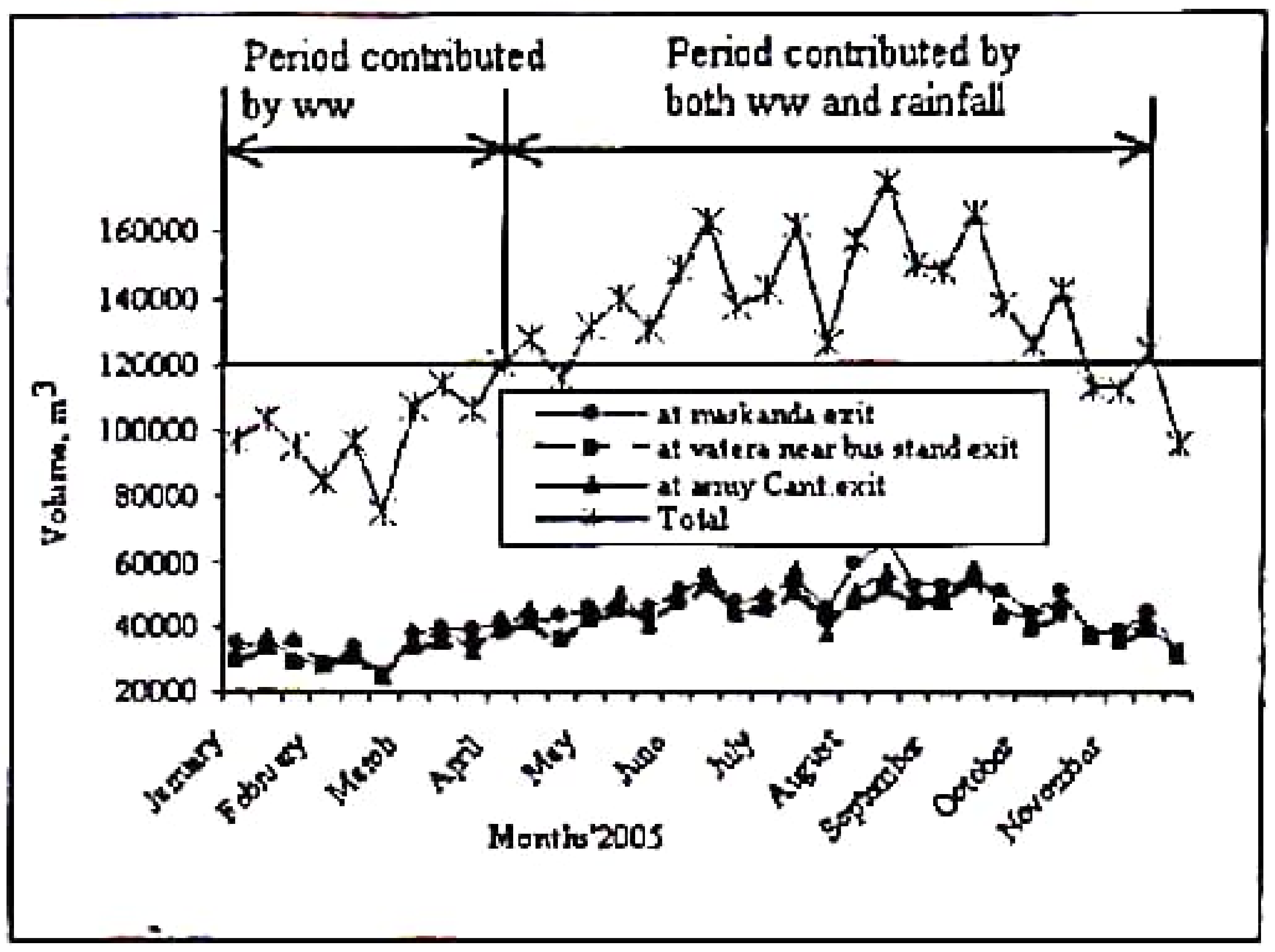

Fig.2 Wastewater discharge during from Mymensingh Municipal area Jan to Nov'2005.

At the farm level, the following basic conditions should be taken into account to make irrigated farming as a success: Wastewater is always available in the periurban areas, free water, doesn't required chemical fertilizer, conserves water, low-cost method for sanitary disposal of municipal wastewater, reduces pollution of rivers, canals and other surface water resources, conserves nutrients, reduce the need for artificial fertilizer, increases crop yields, provides a reliable water supply to farmer and after necessary biological treatment wastewater can be used for fish cultivation (certain species).

3.9 Yield

Farmers informed the authors that wastewater doesn't create any health problem but the total production per ha land is only 2470 to 3200 kgs, which is lower than that is obtained from the normal cultivation method that applies organic or inorganic fertilizers. The reason may be the acidic condition of the soil. To solve the problem CaO should be used.

As regards to availability of wastewater, it is always available (Fig.2). As regards to the quality of the wastewater, the quality and composition of water are not known. The wastewater from the town is flowing through the earthen channel and the whole channel is covered with floating waterhyacinth. This waterhyacinth absorbs the undesirable heavy metals, does the water become suitable for crop cultivation. At the input point the colour of water was blackish and it was less blackish in 2 or 3 km's away from the entrance point.

3.10 Trees availability

Different types of trees are grown in the survey areas. Most of these are Raintree, Ber and Bamboo, and few of these are mango, jackfruit etc. At Maskanda area 50% plants were raintree, 10% Ber, 20% bamboo and 20% other plants. At Digarkanda area raintree was 45%, bamboo was 30% and others 25%. At Chorar Beel area raintree was 60%, others 40%. At Beltoli raintree was 60%, bamboo was 30% and others 10%. At Vatera area raintree was 40%, bamboo 20% and others 40%. Fig.3 shows that trees available in the surveyed area.

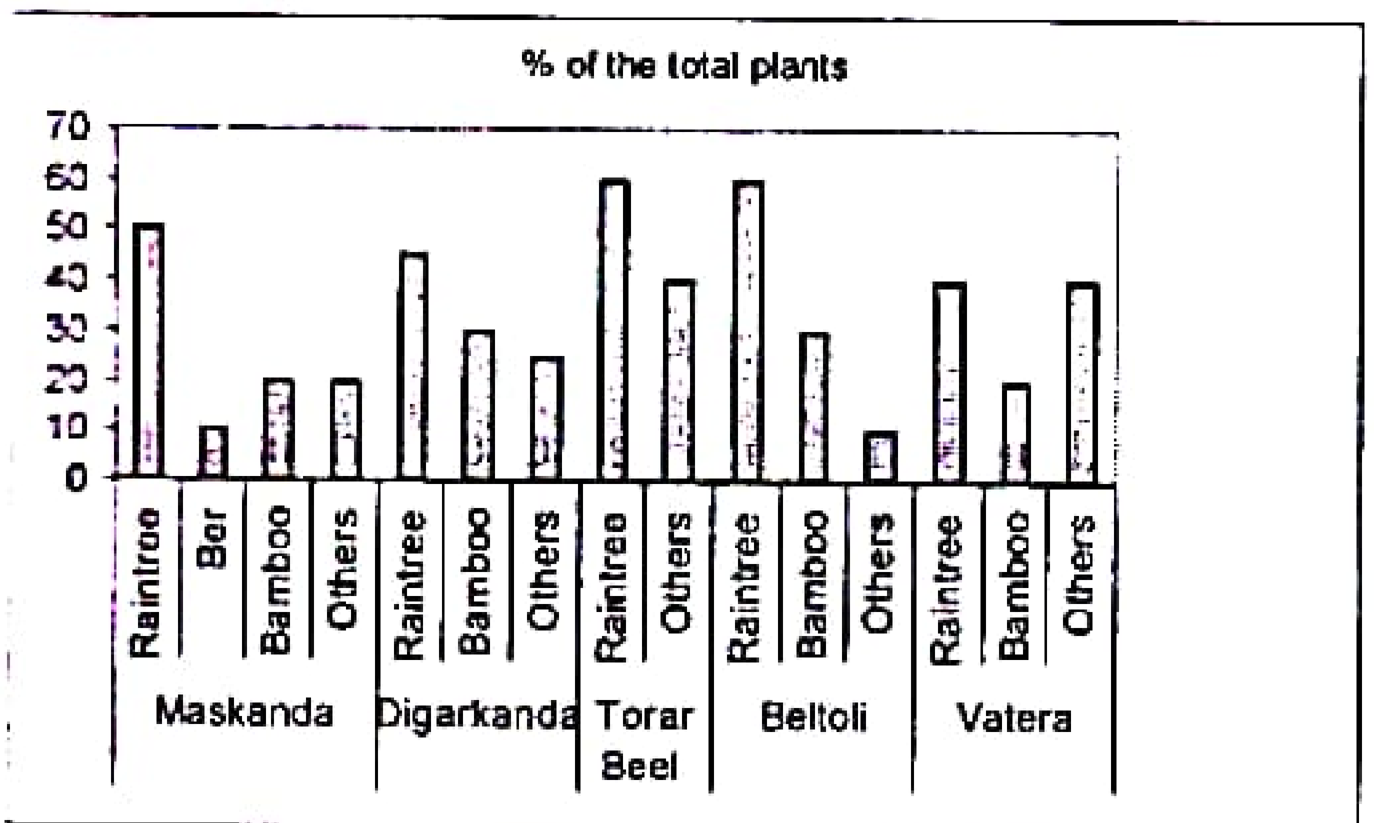

Fig.3 Trees available in the survey area

4. Conclusions

The following conclusions are made based on the above information:

i) Wastewater can be treated using fast growing short rotation plantations, such as rain tree, ber, mortha, bamboo, moringha, jatropha carcas etc.

ii) Wastewater is rich in nutrients and can be used as irrigation water

iii) Wastewater use policy must be formulated and practiced as per state of the art of use and application of wastewater and SRPs in the country.

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