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Cost-benefit analyses of paddy yield from sewage-fed and rain-fed agroe co systems in Burla town of Sambalpur district, Odisha, India

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Abstract

Rice production in India is an important part of the national economy. It is a choice crop for millions of poor and small farmers not only for income but also for household food purpose. There is a gradual decline in availability of fresh water to be used for irrigation in India. As a consequence, the use of sewage and other industrial effluents for irrigating agricultural lands is rising, particularly in peri-urban areas of India. Hence, a case study was undertaken to analyse the cost- benefit ratio of rice yield in a sewage irrigated and rain fed and pond water irrigated rice agroecosystem in Western Odisha, India. Use of the domestic wastewater with minimal fertilizers has shown improvement in the physico-chemical properties of the soil, crop yield and also in the nutrient status as compared to that of the paddy fields receiving pond water for irrigation along with the use of recommended dose of fertilizer. The cost benefit analysis indicated higher auxiliary energy input in site I (pond water irrigated plot) in comparison to site II where sufficient amount of nutrients from sewage were fed to the crops. The benefit for the farmers practising sewage fed irrigation was found to be nearly twofold when compared to the farmers practising pond water irrigation. The present case study gives emphasis on use of domestic water irrigation for grater rice yield and improvement of economic status of the poor farmers of India.

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Introduction

Irrigated rice fields are scientifically considered as agronomically managed temporary wetland ecosystem (Bambaradeniya, 2000). Rice is considered as a staple food and first cultivated crop in Asia (Grist, 1965). Rice is one of the most important cereal crops of India occupying an area of 41.92 million hectare with an annual production of 89.09 million tonnes with an average productivity of 2.13 t ha^{-1} (2009-10) (Tripathi *et al.*, 2014). India is the second largest producer and consumer of rice in the world. Rice production in India crossed the mark of 100 million tonnes in 2011-12 accounting for 22.81% of global production in that year. The productivity of rice has increased from 1984 kg per hectare in 2004-05 to 2372 kg per hectare in 2011-12. During 2011-12, 43.97 Million Hectares of land produced 100 Million Tonnes of rice. According to FAO Statistics Division 2015, the rice yield during 2013 was 159.2 million tonnes. As per BS Reporter, New Delhi, September 30, 2014 in 2014 the area producing rice rises to 37.48 million hectares from 37.42 million hectares in 2013. Department of Agriculture, Govt of Odisha (http:// agriodisha.nic.in/http_public/status%20of%20agricu lture %20in% 20orissa.aspx) reported that ,the State has cultivated area of 61.80 lakh ha out of which 29.14 lakh ha. is high land with Khrrif (during monsoon) Paddy Area of 10.43 lakh ha: 17.55 lakh ha medium land with Khrrif Paddy Area of 15.99 lakh ha and 15.11 lakh ha low land Khrrif Paddy Area of 14.82 lakh ha. The total coverage under Paddy during Kharif is about 41.24 lakh & during Rabi (winter) 3.31 lakh ha. The climate of Odisha is suitable for paddy cropping with a tropical climate, characterized by high temperature, high humidity, medium to high rainfall and short and mild winters. The normal rainfall of the State is 1451.2 mm.

Rice can be cultivated by different methods based on the type of region. But in India, the traditional methods are still in use for harvesting rice. The fields are initially ploughed and then fertiliser is applied which typically consists of cow dung and then the field is smoothed and ready for plantation.

Waste water irrigation has been a common practice world wise for centuries ((Shuval *et al.*, 1986). However, it is important to see the utilization of waste water on physico-chemical and biological properties of soil. Soil, as an acceptor should have minimum adverse effects on crops to be grown, soil characteristics and ground water quality (Ghose, 2013). According to Banerjee (http://www.igep.in/live/hrdpmp/hrdpmaster/igep/ content/e48745/e57806/e61054/e61055/Agriculture WastewaterReuse Background Review.pdf), currently, agriculture accounts for more than 80% of India's water use. But growing demand from other uses such as municipal and industrial, is leading to increased competition among uses, especially near urban areas of India. The increased food production has to come from the available and limited water and land resources which are finite. Neither the quantity of available water nor land has increased since 1950, but the availability of water and land per capita has declined significantly due to increase in global human population (http://www.icrisat.org/what-we do/agroecosystems/projects/Water4Crops/pdfs/Ann ual%20 Report_W4Cs.pdf). However, there is higher risk associated with human health and the environment on the use of wastewater especially in developing countries, where rarely the wastewater is treated and large volumes of untreated wastewater are being used in agriculture (Buechler and Scott, 2006). There are agronomic and economic benefits of wastewater use in agriculture. Irrigation with wastewater can increase the available water supply or release better quality supplies for alternative uses. In addition to these direct economic benefits that conserve natural resources, the fertilizer value of many wastewaters is important. FAO (1992) estimated that typical wastewater effluent from domestic sources could supply all of the nitrogen and much of the phosphorus and potassium that are normally required for agricultural crop production. In addition, micronutrients and organic matter also provide additional benefits. International Water Management Institute (IWMI) research is focused on waste water irrigation is to maximise the benefits to the poor who depend upon the resource while minimizing the risks.

With this backdrop the present work is aimed at comparing the yield of rice in domestic waste water irrigated low land with the yield of rice in an upland pond water irrigated plot and to do a cost benefit analysis of the cropping practice in the above mentioned fields.

Material and methods

Study sites

The study sites are located on two sides of the road connecting NH 6 and Hirakud Dam and on the mid way between Sambalpur University Campus and Burla town (Fig 1). The upland paddy field (Site I) is a pond water irrigated plot and the site II receives domestic sewage water from the inhabitants of South Eastern part of Burla town. Site II is present nearly 8-10 feet down the Site I and in this part of Burla town; there are at least 300 households and a slum pocket, maintaining a population of around 2500. In addition, the inhabitants usually maintain many domestic animals (cows, buffaloes, pigs etc.) in cattle shed close to their habitats. The drainage from the cattle shed also contributes to sewage. In both sites, Swarna variety of rice is cultivated during the period of June to September.

Pattern of Agriculture

The South West monsoon brings abundant rainfall during June to September and continuous flow of domestic sewage in the post monsoon period is also suitable for growing rice in this plot. Hence rice is grown twice a year in these areas: Khrif crop (winter rice) planted in August and harvested in November and Rabi crop (summer rice) extending from February to May. The present work was carried out in Rabi crop period of 2012. Day one (D1) was 25.02.2012 when the seedlings were planted in both the plots. Thereafter, on each 15 days interval the observations were made for 90 days.

Sampling of soil and paddy plants

Top soil and three rice plant from each plot were collected on 15 days gap till harvesting starting from the seedling plantation day. Each crop was applied at recommended NPK dose of fertilizers for treatment. The soil characteristics of the soil on the plantation day were conducted as per the standard protocol. The organic carbon was done following Walkley and Black's titration method (Jackson, 1973), Total Nitrogen by Autokjeltec method, available Phosphorus by Olsen's method (Olsen *et al.*, 1954), and available potassium by Fame photometry method.

For analysis of growth and production three rice plants from each plot were brought to the laboratory and properly washed. The dry root biomass and dry shoot biomass were observed from seedling stage to the up to harvesting. The numbers of filled grains obtained from plants of two plots were weighed and finally cost – benefit analysis was done from the production of two plots All the results obtained were subjected to one way ANOVA using Excel 2007.

Results and discussion

Chemical properties of soil

The soil chemical parameters studied showed acidic nature of soil under waste water irrigation and alkaline soil under pond water irrigated soil. One of the important factors in water quality management is pH. The pH of domestic sewage from different Indian cities has specified by WHO standards vary from 7.0 to 7.5 (Maiti, 2001). However, in present study the soil pH was slightly acidic (6.47-6.66) in sewage water irrigated soil. It may be due to the acidic nature of sewage water. Further, continuous application and decomposition of organic matter of sewage water to the soil caused lowering of pH. Masto *et al.* (2009) suggested that the pH was not affected due to sewage water irrigation, probably due to the improvement in soil buffering capacity owing to increase in soil clay content. The higher Carbon, Nitrogen, Phosphorus and Potassium in the soil of waste water irrigated field in comparison to pond water irrigated soil was due to continuous input of organic matter along with the application of fertilizer. The organic carbon, N, P, and K content of sewage water irrigated soil was higher in comparison to the results obtained by

Ladwani *et al.* (2012) who studied the effect of domestic waste water irrigation on nutrient content of soil and some crops in Nagpur district of India. Our findings was also in agreement with the findings of Singh *et al.* (2012) indicating that the use of the domestic waste water with fertilizers has shown the improvement in the physicochemical properties of the soil, crop yield and also in the nutrient status as compared to that of the resulted from the application of ground water with fertilizer. Further, our observation was also supported by Anderson and Nilssion, (1972); Haque and Sharma, (1980) who observed that the use of domestic wastewater has favorably influenced the crop production; its continuous application for number of years may result in enrichment of nutrients in top soils. Ladwani *et al.* (2012) also opined that domestic wastewater irrigation provides the essential nutrients to the crops. The present study emphasises the use of domestic sewage as an alternative source for irrigating crop lands.

Table 1. Chemical properties of from top soil (0-20cm) of waste water irrigated and pond water irrigated plots.

Days	pH		OC (g %)		TN (g %)		AP (g/m^2)		AK (g/m^2)	
	Site I	Site II	Site I	Site II	Site I	Site II	Site I	Site II	Site I	Site II
D1	7.4±0.21	6.51±0.23	1,04±0.05	1.03±0.02	0.38±0.05	0.58±0.08	0.33±0.08	2.2±0.1	24.8±5.3	35.8±3.6
D2	7.48±0.22	6.51±0.21	1.06±0.04	1.04±0.03	0.4±0.04	0.61±0.07	0.36±0.21	2.4±0.17	26.3±4.4	37.96±2.65
D3	7.78±0.21	6.47±0.16	0.97±0.09	1.34±0.04	0.51±0.047	0.61±0.1	3.2±0.45	3.93±0.23	22.7±2.83	40.6±2.11
D4	7.56±0.1	6.66±0.12	0.96±0.02	1.47±0.04	0.55±0.1	0.65±0.09	2.26±0.58	3.93±0.6	20.83±5.07	30.1±7.1
D5	7.18±0.26	6.5±0.29	0.95±0.13	1.47±0.04	0.88±0.1	0.89±0.07	3.2±0.55	5.01±0.52	20.86±2.57	35.53±2.65
D6	7.82±0.14	6.36±0.31	1.02±0.12	1.36±0.03	1.01±0.15	1.19±0.19	3.8±0.17	5.01±0.8	22.06±2.76	32.26±0.98

Site I indicates pond water irrigated plot and Site II represents Waste water irrigated.

Productivity analysis

For the productivity study the weight of the seedling plants were taken on 25.02.2012. The weights of the seedlings were 4.57 ± 0.86 and 4.54 ± 0.79 in site I and Site II respectively in D1. Thereafter, on each 15 days interval the dry shoot biomass (g/bush) was taken from each site (Fig. 2).

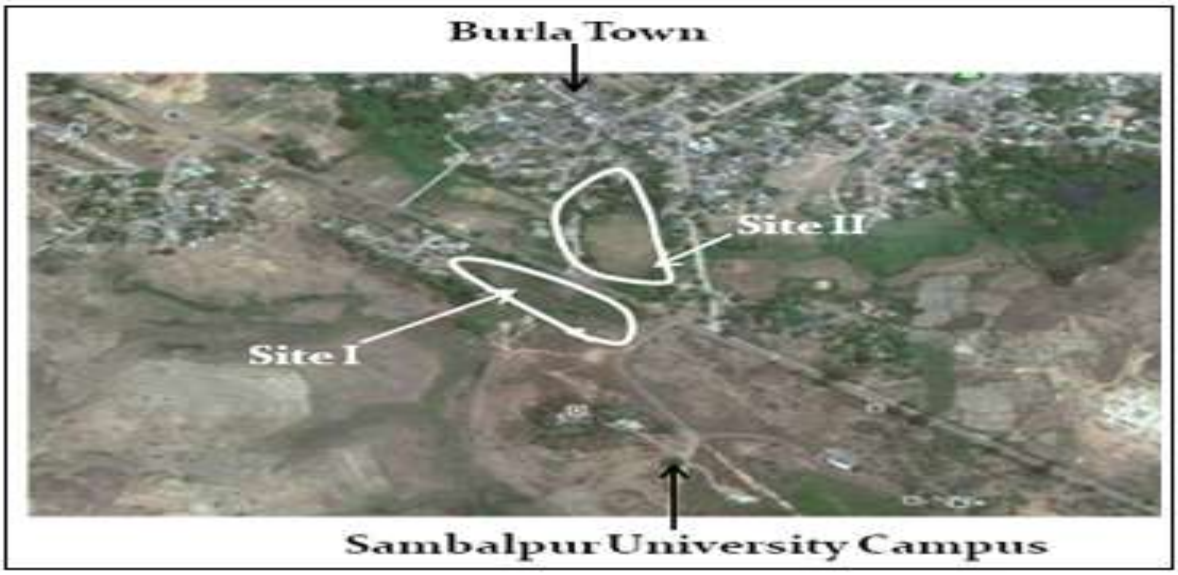

Fig. 1. The study site at Burla town of Odisha state, India.

The dry shoot biomass was significantly high in site II in comparison to site I as revealed from one way ANOVA (F = 49961.75, p = 0.001). Sharp increase in shoot biomass was observed in Site II. Towards harvesting (90th day), sharp decrease in shoot biomass was observed as the paddy plants had already achieved senescence. Similar observation was found in case of root biomass (Fig. 3). ANOVA revealed significantly higher root biomass (F= 1827.4, p= 0.001) in site II as compared to site I.

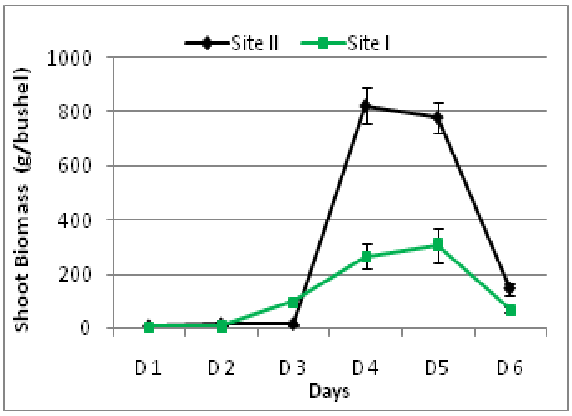

Fig. 2. Dry shoot biomass (g/ bush) during 15 days interval.

Cost benefit analysis (INR Rs/- expenditure/ income/ acre)

For cost benefit analysis, seed cost, ploughing cost, sowing cost, weeding cost, fertilizer cost, pesticide cost, and harvesting cost per acre for both the plots were analysed (Fig. 4 and Fig. 5).

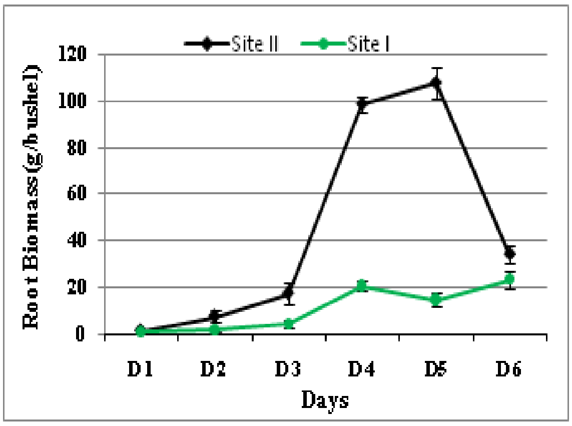

Fig. 3. Dry root biomass (g/ bush) during 15 days interval.

The cost benefit analysis indicated higher auxiliary energy input in site I (pond water irrigated plot) in comparison to site II where sufficient amount of nutrients from sewage were fed to the crops. Further, the analysis of soil chemical parameters indicated higher nutrient content in sewage fed plot in comparison to pond irrigated plot. This is in agreement with the findings of Singh *et al.* (2012).

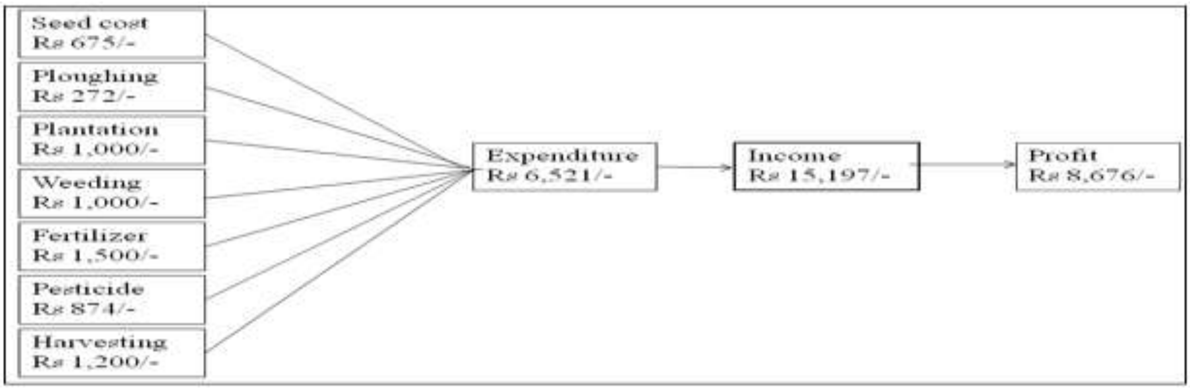

Fig. 4. Benefit from site I is per acre (all the costs are per acre).

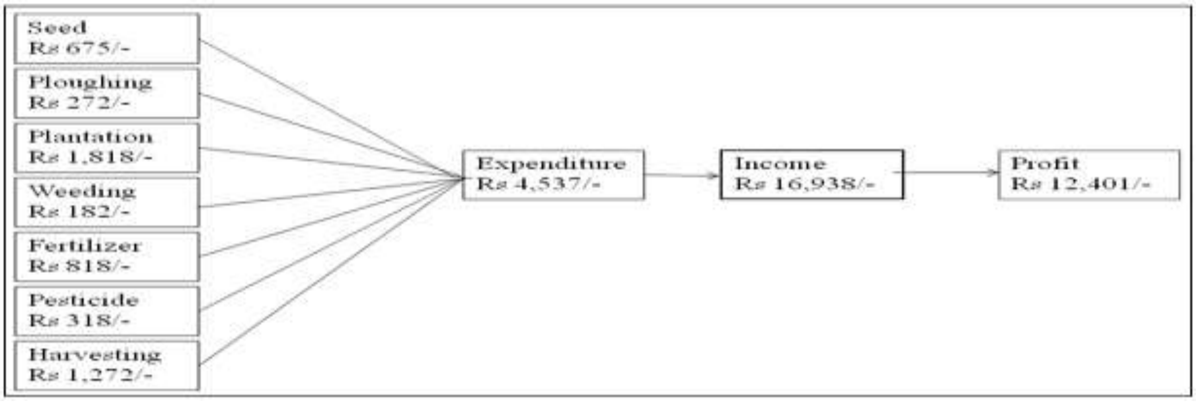

Fig. 5. Benefit from site II is per acre (all the costs are per acre).

Conclusion

The present investigation was carried out to observe the impact of sewage water on soil characteristics and crop production. Use of the domestic waste water with fertilizers has shown the improvement in the physicochemical properties of the soil, crop yield and also in the nutrient status as compared to that of the results obtained from the application of pond water with fertilizer. It is worth mentioning here that, the disposal of waste water through crop irrigation works as a living treatment system. The macro and micronutrients of domestic waste water, if utilized by the plants can enhance their production and gives significantly higher profit to the farmers irrigating the domestic sewage in their crop fields in comparison to the farmers practising pond water irrigation in their crop fields. This clearly justify that crop production in domestic sewage fed plots is an eco-friendly treatment and disposal system. At the same time it is advisable to assess the health risk if any for the farmers and consumers using the crops derived from the plots receiving untreated sewage irrigation.

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