

Original Research Article

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Maize Response, Changes in Soil Available Nutrients and Microbial Population as Influenced by Brewery Wastewater Irrigation

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ABSTRACT

Keywords

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The brewing industry is one of the largest users of water. Even though substantial technological improvements have been made in the past, it has been documented that approximately 3 to 10 litres of wastewater is generated per litre of beer. Field experiments was conducted at United Breweries (UB) Ltd., Nelamangala and Zonal Agricultural Research Station, UAS, GKVK, Bengaluru in sandy loam soil results revealed that application of 150% RDN through TBWW as 50% basal and 50% in three irrigations recorded significantly higher grain yield (39.6 q ha⁻¹) and stover yield (69.9 q ha⁻¹) of maize compared to all other treatments. The maximum total nitrogen, phosphorus and potassium uptake (157.5, 40.7 and 151.9 kg ha⁻¹, respectively) was recorded in 150% recommended N through TBWW as 50% basal and 50% in three irrigations (T₃). Similarly same treatment recorded higher fungi, bacterial and actinomycetes (52.19 cfu x10⁵, 31.19 cfu x10⁴ and 19.58 cfu x10³, respectively). Increasing brewery wastewater application resulted increasing the quantities of microbial population.

Introduction

In arid and semi-arid regions, wastewater is considered a valuable source of irrigation water and a fertilizing material. (Al-Rashed *et al.*, 2000; Tarchitsky *et al.*, 1999). Pollution of soil and water bodies is a serious problem ever since man started disposing sewage and industrial effluents into water bodies and on land.

Their efficient use is indispensable for sustainable agriculture in view of the shrinking land, man and water, man ratios, increasing fertilizer prices, haunting energy crisis, wide spread pollution and fast degradation and depletion of natural resources.

When wastewater is used properly for irrigation it is considered an environmentally sound disposal practice (Papadopoulos, 1995). Such a proper use can relatively minimize pollution of the ecosystem which otherwise would be contaminated by direct disposal of wastewater into surface or ground water (Hespanhol, 1990; Gori *et al.*, 2000). Wastewater contains huge quantity of nutrients which are essential for plants growth and development and it also adds the organic carbon to the soil. Thus leads to use as fertilizer and improves soil fertility and productivity. Application of 0, 25, 50, 75 and 100 % effluent decreased the organic carbon, N, P, Na, and Mg concentration in the soil

while K, Ca, C/N ratio, soil pH were increased. There were no changes observed in the soil textural class. The growth of maize plant as well as chlorophyll content was enhanced with brewery effluent treatments when compared with the control (Orhue *et al.*, 2005). Combined use of brewery waste water sludge and two different types of composts increased the germination per cent and dry matter yield of chili and pumpkin when compared to brewery wastewater sludge or compost alone. Brewery wastewater sludge has recorded higher water retention capacity when compared to compost. Thus, there is a need to develop eco-friendly measures to utilize these liquid wastes profitably (Kangachandran and Jayaratne, 2006). In addition to fertilizer source also serves the problem of disposal and reduces scarcity of water to agriculture in peri-urban areas.

Several researchers has been studied the use of wastewater irrigation on different crops in different weather conditions and site locations. Campbell *et al.*, (1983) stated that a weekly application of 25 mm of wastewater was enough to supply 40-80% of the corn N requirements and all P needed. Other researchers reported similar results (Elliot and Stevenson, 1997). Ouazzani *et al.*, (1996) found that meadows irrigated with wastewater received N and P in amount equivalent or superior to the recommended dose of fertilizers for meadows. Jamjoum and Khattari (1986) found that corn yield was increased by irrigation with wastewater and they attributed this increase to the enhancement of nutrient uptake and improvement of the physical properties of the soil. Keeping this the background use of brewery wastewater irrigation on maize and soil properties have been conducted and results of the experiment is presented below.

Material and Methods

Field experiments were conducted at United

Breweries (UB), Nelamangala and Zonal Agricultural Research Station, UAS, GKVK, Bengaluru located in Eastern Dry Zone of Karnataka and situated at 12° 11' North latitude 76° 69' East longitude with an altitude of 980 meters above mean sea level during 2009 and 2010. The soils of the experimental site at UB Ltd, Nelamangala were sandy loam in texture and soil was neutral in reaction (pH 7.19). Electrical conductivity of soil was 0.18 dSm⁻¹. The organic carbon content was 0.58 per cent. The available nitrogen was medium (315.8 kg ha⁻¹), phosphorus was low (13.17 kg ha⁻¹) and potassium (103.4 kg ha⁻¹) was low. At ZARS, GKVK, the soil was sandy clay loam in texture, acidic in reaction (pH 6.4) and electrical conductivity of 0.15 dSm⁻¹. The organic carbon content was 0.56 per cent. The available nitrogen was low (221.34 kg ha⁻¹), phosphorus was low (19.13 kg ha⁻¹) and potassium (265.25 kg ha⁻¹) was medium. The experiments were laid out in randomized complete block design (RCBD) consisting of nine treatments and replicated thrice. The hybrid Maize (NAH-2049) is used as test crop. The treatment details and corresponding symbol used in the study are as follows T₁: fresh water + RDF, T₂: RDN through UBWW as 50 % basal and 50 % in three irrigations, T₃: RDN through UBWW as 25 % basal and 75 % in three irrigations, T₄: RDN through TBWW as 50 % basal and 50 % in three irrigations, T₅: RDN through TBWW as 25 % basal and 75 % in three irrigations, T₆: 150% RDN through UBWW as 50 % basal and 50 % in three irrigations, T₇: 150% RDN through UBWW as 25 % basal and 75 % in three irrigations, T₈: 150% RDN through TBWW as 50 % basal and 50 % in three irrigations, T₉: 150% RDN through TBWW as 25 % basal and 75 % in three irrigations. The experimental results were statistically scrutinized as suggested by Panse and Sukhatme (1985). The critical difference was worked out at 5 per cent (0.05) probability levels.

Note

RDF- Recommended dose of fertilizers,
RDN- Recommended dose of nitrogen,
UBWW- Untreated brewery wastewater,
TBWW- Treated brewery wastewater

Results and Discussion

The grain yield depends on the synthesis and accumulation of photosynthates and their distribution among various plant parts. The synthesis, accumulation and translocation of photosynthates depend upon efficient photosynthetic structure as well as the extent of translocation into sink (grains) and also on plant growth and development during early stages of crop growth. The production and translocation of synthesized photosynthates depends upon mineral nutrition supplied either by soil or through foliar application. Most of the photosynthetic pathways are dependent on enzymes and co-enzymes which are synthesized from mineral elements such as nitrogen, phosphorus and potassium.

Nitrogen improves plant growth and productivity by having direct effect on the metabolism of plants. Nitrogen is usually applied through organic or inorganic sources. Cereals consume more amount of nitrogen when compared to other major nutrients, as it is essential in almost all the metabolic processes. The time of application as well as the stage of plant growth determines the uptake and translocation of nitrogen. Phosphorus and potassium supply in early vegetative stage has greater influence on yield of crops. Hence, major nutrients play a vital role in growth, yield and quality of crops.

In field experiment of maize yields differed slightly during first (2009) and second (2010) year of experiments, but the pattern of response to brewery wastewater used for irrigation was similar in both the years. Therefore, only pooled data of the two years

are presented (Table 1).

Grain and stover yield

In the present study, pooled results revealed that grain and stover yield of maize differed significantly due to brewery wastewater irrigation. Application of 150% RDN through TBWW as 50% basal and 50% in three irrigations recorded highest grain and stover yield (39.6 and 69.9 q ha⁻¹, respectively) compared to all the other treatments. However, it was on par with T₆ (39.1 and 69.2 q ha⁻¹, respectively), T₉ (38.2 and 67.6 q ha⁻¹, respectively) and T₇ (37.8 and 66.3 q ha⁻¹, respectively). Increase in grain yield of maize is due to higher plant height, more number of leaves, leaf area, leaf area index, total dry matter accumulation, number of cobs plant⁻¹, more cob length, number of rows cob⁻¹ and test weight observed in this treatment. These results are in conformity with the findings of Efstathios *et al.*, (2009) and Moazzama *et al.*, (2010) revealed that treated urban wastewater effectively increased the yield of cultivated forage crop species due to the nutritive value of the wastewater, although the differences were not statistically significant.

Field experiments at Nigeria agricultural farm during 2006 and 2007 results revealed that application of palm oil mill effluent in maize as organic fertilizer increased dry matter, grain yield, stover yield and grain NPK content (Nwoko, 2010) and Selim (2008), reported that crops irrigated with secondary treated wastewater performed equally well or significantly better than those irrigated with canal water. Seed and biological yields of plants given wastewater in the absence of chemical fertilizers were nearly equal to those of plants given the recommended dose of chemical fertilizers, indicating that wastewater could provide an adequate amount of N, P and K to cover crop requirements at different growth stages. During 2013, Senthilraja *et al.*, revealed that brewery

wastewater application produced significantly more dry matter than the other treatments in Maize, Sunflower and Sesame crops. The higher concentration of brewery wastewater irrigation significantly increases the dry matter production such effect was more pronounced in maize.

Changes in soil properties

After harvest of maize crop soil samples were analyzed for following parameters like pH, EC, available nitrogen, phosphorus and potassium results presented below (Table 2).

Soil reaction did not differ significantly due to brewery wastewater irrigation to maize. However, marginal increase in pH was observed in treatments which received treated brewery wastewater irrigation. Salt content in soil differed significantly due to brewery wastewater irrigation. Application of treated brewery wastewater marginally increased the EC after the harvest of maize when compared to EC of soil which received freshwater plus recommended dose of fertilizers and also untreated brewery wastewater EC value of soil. This is attributed to the use of treated brewery wastewater containing appreciable amount of salts for irrigation to soil has enhanced the EC. The results are in accordance with Hati *et al.*, (2005) and Bhagyalakshmi (2009) reported increased pH and electrical conductivity of soil with usage of spent wash.

Available N in soil differed significantly due to brewery wastewater irrigation. Application of 150% RDN through UBWW as 25% basal and 75% in three irrigations recorded higher available N in soil followed by T₉, T₆ and T₇ (186.3, 185.4, 184.0 and 183.6 kg ha⁻¹, respectively) compared to all the other treatments (Fig. 1). This might be due to slow release of N from brewery wastewater which

decreased the N loss from soil and maintained higher N potential throughout the plant growth period. These improvements in N uptake could be supported by the studies of Sukanya and Meli (2003) who observed that spentwash consisting of N chiefly in organic colloidal form functioned as slow releasing fertilizer upon application to soil. Vijay Krishna (2005) found that raw coffee pulp effluent irrigation recorded higher soil available nitrogen (155 kg ha⁻¹) as compared to freshwater irrigation + RDF (83.62 kg ha⁻¹).

Available P in soil varied significantly due to application of brewery wastewater irrigation and freshwater plus recommended dose of fertilizers (Fig. 1). This was due to organically bond P in brewery wastewater, which takes some time to get decomposed into available form. Zalawadia *et al.*, (1997) reported that two thirds of the phosphorus in spent wash was in organic form. Some researchers recorded improved available P in soil with application of spent wash.

Available potassium content of soil differed significantly due to brewery wastewater irrigation. Maximum soil available K was accumulated in treatments receiving brewery wastewater.

This is due to the fact that, brewery wastewater containing substantial amount of K (0.02 %) is mostly in ionic form and that becomes immediately available to plants. The results obtained from the present study are in conformity with the findings of Patak *et al.*, (1999) observed appreciable increase in available potassium status in soil irrigated with distillery effluent. Basavalingaiah *et al.*, (2009) reported that soil available potassium was significantly increased due to raw coffee effluent irrigation (461.4 kg ha⁻¹) as compared to freshwater irrigation (286.7 kg ha⁻¹).

Table.1 Grain and stover yield of maize as influenced by brewery wastewater irrigation

Treatments	Grain yield (q ha ⁻¹)			Stover yield (q ha ⁻¹)		
	2009	2010	Pooled	2009	2010	Pooled
T ₁	27.0	33.9	30.5	45.8	56.1	51.0
T ₂	30.2	34.4	32.3	48.7	58.4	53.5
T ₃	27.6	33.7	30.7	46.9	57.3	52.1
T ₄	30.4	34.6	32.5	51.7	58.6	55.2
T ₅	28.6	33.7	31.2	50.8	58.3	54.6
T ₆	35.7	42.5	39.1	64.5	73.9	69.2
T ₇	35.0	40.6	37.8	61.4	71.2	66.3
T ₈	36.7	42.6	39.6	65.1	74.6	69.9
T ₉	35.5	40.9	38.2	63.3	71.9	67.6
S. Em±	1.01	1.97	1.54	2.02	3.44	3.00
C. D. at 5%	3.05	5.92	4.43	6.07	10.30	8.63

Note:

T₁ - Fresh water + RDF

T₃ - RDN through UBWW as 25 % basal and 75 % in three irrigations

T₅ - RDN through TBWW as 25 % basal and 75 % in three irrigations

T₇ -150 % RDN through UBWW as 25 % basal and 75 % in three irrigations

T₉ -150 % RDN through TBWW as 25 % basal and 75 % in three irrigations

Recommended dose of fertilizer: 150:75:40 kg N, P₂O₅ and K₂O ha⁻¹ for T₁

T₂ - RDN through UBWW as 50 % basal and 50 % in three irrigations

T₄ - RDN through TBWW as 50 % basal and 50 % in three irrigations

T₆ -150 % RDN through UBWW as 50 % basal and 50 % in three irrigations

T₈ -150 % RDN through TBWW as 50 % basal and 50 % in three irrigations

UBWW- Untreated Brewery Wastewater, TBWW- Treated Brewery Wastewater

FYM: 10 t ha⁻¹ common for all the treatments

Table.2 pH, EC, available nitrogen, phosphorous and potassium as influenced by brewery wastewater irrigation

Treatments	pH	EC	Kg ha ⁻¹		
			Av. N	Av. P	Av. K
T ₁	7.38	0.18	168.7	21.8	144.7
T ₂	6.44	0.17	177.2	27.8	146.7
T ₃	6.40	0.15	178.6	28.4	147.6
T ₄	7.41	0.22	177.3	27.0	146.5
T ₅	7.40	0.22	178.1	28.4	147.4
T ₆	6.38	0.19	184.0	33.3	151.9
T ₇	6.39	0.18	186.3	35.0	152.3
T ₈	7.37	0.24	183.6	33.3	151.1
T ₉	7.38	0.24	185.4	33.9	152.3
S. Em±	0.06	0.03	1.55	1.57	1.08
C. D. at 5%	0.17	0.09	4.47	4.51	3.11

Note:

T₁ - Fresh water + RDF

T₃ - RDN through UBWW as 25 % basal and 75 % in three irrigations

T₅ - RDN through TBWW as 25 % basal and 75 % in three irrigations

T₇ -150 % RDN through UBWW as 25 % basal and 75 % in three irrigations

T₉ -150 % RDN through TBWW as 25 % basal and 75 % in three irrigations

Recommended dose of fertilizer: 150:75:40 kg N, P₂O₅ and K₂O ha⁻¹ for T₁

T₂ - RDN through UBWW as 50 % basal and 50 % in three irrigations

T₄ - RDN through TBWW as 50 % basal and 50 % in three irrigations

T₆ -150 % RDN through UBWW as 50 % basal and 50 % in three irrigations

T₈ -150 % RDN through TBWW as 50 % basal and 50 % in three irrigations

UBWW- Untreated Brewery Wastewater, TBWW- Treated Brewery Wastewater

FYM: 10 t ha⁻¹ common for all the treatments

Fig.1 Available nitrogen, P₂O₅ and K₂O (kg ha⁻¹) as influenced by brewery wastewater irrigation in soil after harvest of maize

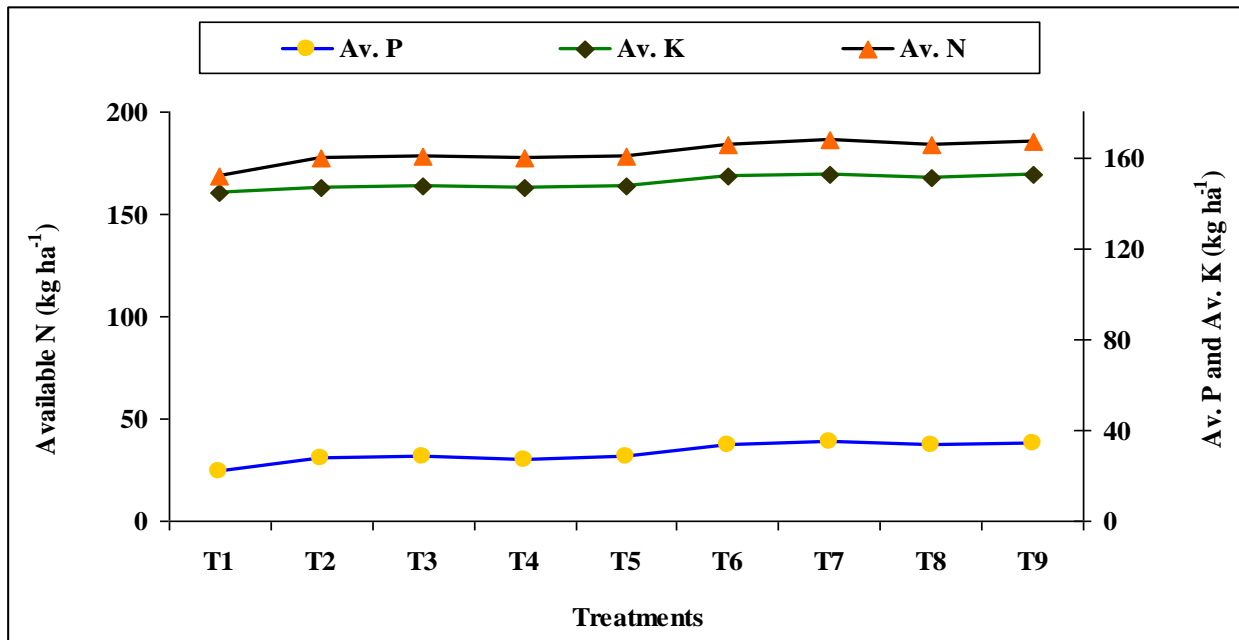
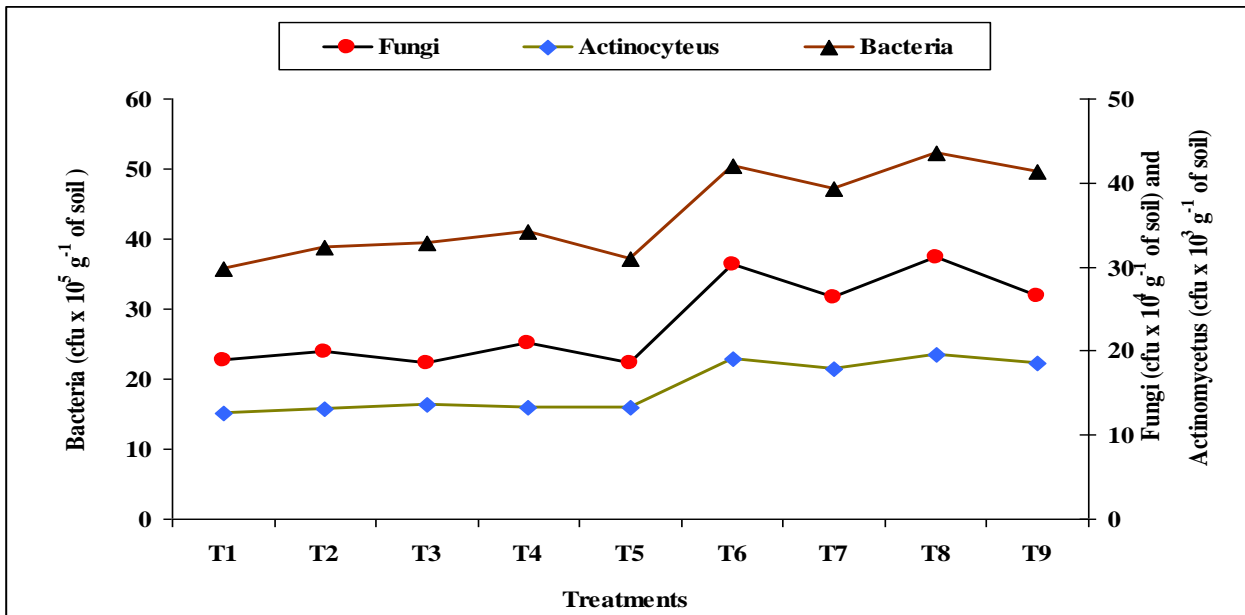


Fig.2 Soil microbial population as influenced by brewery wastewater irrigation on maize



Soil beneficial microorganisms

The soil beneficial microorganisms such as soil fungi, bacteria, actinomycetes, N-fixers and P-solublizer populations differed

significantly due to brewery wastewater irrigation (Fig. 2). The application of 150% RDN through TBWW as 50% basal and 50% in three irrigations recorded significantly highest fungi, bacterial and actinomycetes

(52.19 cfu x10⁵, 31.19 cfu x10⁴ and 19.58 cfu x10³, respectively) followed by 150% RDN through UBWW as 50% basal and 50% in three irrigations (50.51 cfu x10⁵, 30.35 cfu x10⁴ and 19.08 cfu x10³, respectively), 150% RDN through TBWW as 25% basal and 75% in three irrigations (49.53 cfu x10⁵, 26.57 cfu x10⁴ and 18.60 cfu x10³, respectively) and 150% RDN through UBWW as 25% basal and 75% in three irrigations (47.19 cfu x10⁵, 26.40 cfu x10⁴ and 17.78 cfu x10³, respectively) compared to all the other treatments

Soil pH above neutral range favours the growth and multiplication of bacteria. Similar results have been observed by Srinivasamurthy *et al.*, (2008) indicated that there was no adverse effect of spent wash applied as ferti-irrigation to maize crop on the soil microbial population. On the other hand, brewery wastewater applied plots had slightly higher population of microbial population (Fungi, Bacteria and Actinomycetes). This is a positive aspect and is in favour of utilization of brewery wastewater as a source of nutrients in crop production. Jnaneesha (2008) reported that soil fungi, bacterial and actinomycetes population were increased due to application of coffee pulp effluent. The results are in conformity with the findings of Ekhaise and Anyasi (2005) were analyzed brewery wastewater for total microbial population, which had values ranging from 1.0 x 10³ to 4.8x10³ cfu ml⁻¹ and 1.3x10⁷ to 5.7x10⁷ cfu ml⁻¹ for the fungal and bacterial isolates respectively. Total coli-form counts ranged from 4.3x10 MPN/100 ml to 38x10 MPN/100ml. Microorganisms isolated include *Sacchromyces cereviceae*, *Aspergillus niger*, *Penicillium* sp., *Geotrichum* sp. *Candida* sp., *Proteus* sp. *Staphylococcus* sp, *Escherichia coli*, *Streptococcus faecalis* and *Bacillus* sp. Shang Ran (2003) observed that increasing the ratio of wastewater concentration continuously increasing the quantities of bacteria, actionomycetes, aerobic

cellulose-decomposing bacteria, nitric acid bacteria, nitrous acid bacteria, free-living nitrogen-fixing bacteria and decreasing later. At higher wastewater concentration the nutrient components in sewage could stimulate fungus, nitrifying bacteria, denitrifying bacteria and some anaerobic bacteria to propagate. Irrigation concentration of brewery wastewater sludge with the optimum ratio of water to sewage of i.e. 2:1 or 1:2 found best and the higher sewage concentration would be disadvantageous to plant growth.

References

- Ai-Rashed, M.F. and Sherif, M.M. Water resources in the GCC countries: an overview. *Water Resour. Mgt.* 2000, 14 (1), 59-73.
- Basavalingaiah, Bhaskar, S., Girisha. H. C. and Srinivasamurthy, c. A., 2009, Utilization of coffee pulp effluent as a source of irrigation on growth, yield, quality of baby corn and chemical properties of soil. *National Seminar on Sustainable Waste Management*, Mangalore, P. 52.
- Bhagyalaksmi, 2009, Studies on the effect of industrial effluent on soil properties and crop growth. *Ph.D., Thesis*, Univ. Agric. Sci., Bengaluru.
- Campbell, W. F. Miller, R. W. Screeg, T. M., and Alfalfa, 1983, Sweet corn and wheat responses to long term application of municipal wastewater to crop land. *J. Environ. Qual.* 2, 243-249.
- Efstathios, T., Martha, L., Ioannis, P., Thomas, S., Fokion, P., Maria, T. and Paraskevi, M., George, V., 2009, The effect of treated urban wastewater on soil properties, plant tissue composition and biomass productivity in berseem clover and corn. *J. Food Agric. Envt.*, 7(3-4):782-786.

- Ekhaise, F. O. and Anyasi, C. C., 2005, Influence of breweries effluent discharge on the microbiological and physicochemical quality of Ikpoba, River, Nigeria. *African J. Biotech.*, 4(10):1062-1065.
- Elliott, L. F. and Stevenson, F. J. 1977. Soils for Management of Organic Wastes and Wastewaters; SSSA: Madison, WI,
- Gori, R.; Ferrini, F.; Nicese, FP.; Lubello, C. 2000, Effect of reclaimed wastewater on the growth and nutrient content of three landscape shrubs. *J. Environ. Hortic.*, 18 (2), 108-114
- Hati, K. M., Biswas, A. K., Bandyopadhyay, K., Mandal, K. G. and Misra, A. K., 2005, Influence of added spentwash on soil physical properties and yield of wheat under soybean-wheat system in Vertisol of central India. *J. Plant Nutr. Soil Sci.*, 167: 584-590.
- Hespanhol, I. 1990, Guidelines and integrated measures for public health protection in agricultural reuse systems. *Aqua*, 39 (4), 237-249.
- Jamjoum, K. I. and Khattari, S. K., 1986, Effect of wastewater and sludge application on soil, corn plant composition and production in Zizia Region. *Dirasat*. 15 (11), 29-44.
- Janeesh, A. C., 2008, Effect of coffee pulp effluent on growth, yield and quality of hybrid Napier grass. *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Bengaluru, India.
- K. Senthilraja*, P. Jothimani and G. Rajannan, 2013, Effect of brewery wastewater on growth and physiological changes in maize, sunflower and sesame crops. *Intr J Life Sci. Edu. Res.*, 1(1), pp. 36 – 42.
- Kanagach and Ran, K. and Jayaratne, R., 2006, Utilization potential of brewery waste water sludge as an organic fertilizer. *J. Inst. Brew.* 112(2): 92–96.
- Moazzam, A. S., Shahid, S., Omme, H. and Suriya, J., 2010, Irrigation of sorghum crop with waste stabilization pond effluent: growth and yield responses. *Pakistan J. Bot.*, 42(3): 1665-1674.
- Nwoko C. O., 2010, Evaluation of palm oil mill effluent to maize (*Zea mays* L.) crop yield, tissue nutrient content and residual soil chemical properties. *Australian J. Crop Sci.*, 23 (1):56-62
- Orhue, E. R., Osaigbovo, A. U., Osahon, O. and Dennis, E. 2005, Growth of Maize (*Zea mays* L.) and Changes in some chemical properties of an ultisol amended with brewery effluent. *African. J. Biotech.*, 4(9): 973 – 978.
- Quazzani, N., Bousseihaj, K. and Abbas, Y. 1996, Reuse of wastewater treated by infiltration percolation. *Water Sci. Technol.*, 33 (10-11), 401-408.
- Panase, V. G. and Sukhatme P. V., 1985, Statistical methods for agricultural workers, ICAR Publications, New Delhi. Pp. 1 – 21.
- Pathak, H., Joshi, H. C., Chaudhary, A., Chaudhary, R., Kalara, N. and Dwivedi, M. K., 1999, Soil amendments with distillery effluent for wheat and rice cultivation. *Water, Air Soil Poll.*, 113: 133-140.
- Papadopoulos, 1995, Wastewater Management for Agriculture Protection in the Near East Region; FAO, Regional Office for the Near East: Cairo, Egypt.; Tech. Bull.
- Selim, M. M., 2008, Evaluation of the re-use of treated wastewater for irrigation. *Acta Agron. Hungarica*, 56(4):0161-0238.
- Shang Ran, 2003, Influence of brewery wastewater irrigation on soil microflora. College of Resources and Environment, Shandong Agril. Univ. *Taian*, Shandong.
- Srinivasamurthy, C. A., Bhaskar, S. and Balakrishna, A. N., 2008, *Utilization*

- of distillery spentwash for agricultural purpose.* Technical bulletin, Pub. Department of Soil Science and Agricultural Chemistry, Univ. Agric. Sci., Bengaluru.
- Sukanya, T. S. and Meli, S. S., 2003, Performance of *rabi* wheat under distillery effluent irrigation. *Karnataka J. Agric. Sci.*, 16(3): 447-450.
- Tarchitsky, J., Golobati, Y., Keren, R. and Chen, Y., Wastewater effect on Montmorillonite suspensions and hydraulic properties of sandy soils. *Soil Sci. Soc. American. J.* 1999, 63 (3), 554-560.
- Vijay Krishna, N., 2005, Effect of coffee pulp effluent on growth, yield and quality of rice, *M.Sc. (Agri.) Thesis*, Univ. Agric. Sci., Bengaluru. India.
- Zalawadia, N. M. and Raman, S. J., 1994, Effect of distillery wastewater with graded fertilizer levels on sorghum yield and soil properties. *Indian Soc. Soil Sci.*, 42: 575-579.
- Zalawadia, N. M., Raman, S. and Patil, S. G., 1997, Influence of diluted spent wash of sugar industries application on yield and uptake by sugarcane and changes in soil properties. *J. Indian Soc. Soil Sci.*, 45:767-769.

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