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WASTEWATER TREATMENT- A BEST ALTERNATIVE TOWARDS GREEN AND SUSTAINABLE AGRICULTURAL PRODUCTION

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Abstract: *Wastewater treatment is the need of the hour especially in agriculture which is gaining wider acceptance in many parts of the world. An estimated 38354 million litres per day (MLD) sewage is generated in major cities of India, but the sewage treatment capacity is only of 11786 MLD. Similarly, only 60% of industrial wastewater, mostly large scale industries, is treated. As population growth is increasing dramatically, per capita use of water ultimately increases industrial and of the agricultural sector all put pressure on water resources. Many irrigated areas around the world are experiencing water shortages due to several factors, such as climate change and surface and groundwater pollution. Hence, there is an urgent need for efficient water resource management through enhanced water use efficiency and waste water recycling. Under these circumstances, treated wastewater use can help to mitigate the damaging effects of local water deficits. This treated urban wastewater made re-use for the irrigation of crops. There is the need to better define acceptable microbiological contamination levels of different sources of irrigation water as used on different crops and this wastewater treatment useful for irrigation purpose and also increases soil fertility.*

Keywords: *Wastewater, Bacteria, Treatment, Nutrient, Irrigation*

Introduction: Treated wastewater not only offers an alternative water irrigation source, but also the opportunity to recycle plant nutrients. Its application might ensure the transfer of fertilizing elements, such as nitrogen (N), phosphorous (P), potassium (K^+), organic matter, and major-nutrients and micro-nutrients, into agricultural soil. Hence, wastewater nutrients can contribute to crop growth, although by periodic monitoring and proper treatment of wastewater is necessary to avoid any imbalance in the nutrient supplies, which might cause excessive vegetative growth, uneven plant and/or fruit maturity, and/or reduced qualitative/quantitative aspects of yields [1].Wastewater is also a rich source of plant nutrients, therefore soils irrigated with wastewater are enriched in nutrients. Hence, doses of fertilizers to be applied should be adjusted according to the nutrient contents in wastewater, amount of wastewater to be applied and crop nutrient requirement. Soil testing should also be carried on regular basis to check imbalanced nutrition or soil sickness [3].

An experiment has conducted to compare the effect of ground water and treated agro-industrial waste water on tomato crop [6]. The majority of the studies conducted on wastewater applications in agriculture have focused mainly on reclaimed urban effluents. The focus should be given to determine the effects of treated agro-industrial wastewater on crop performance. In particular, the objectives should (i) to evaluate the effects of the wastewaters on qualitative and quantitative aspects of particular crop production; (ii) to assess the impact of the wastewaters on the microbiological contamination of crop and the microbiological soil properties. Two experimental irrigation treatments were applied to the tomato plants: irrigation with groundwater (GW), and irrigation with treated wastewater (TW). The GW was from a water source that is commonly applied for crop irrigation in the experimental area. The TW used in this study was taken from the wastewater treatment plant that purifies all of the wastewater produced by the company during their industrial processing of Tomato crop [11]. The experiment was laid out in a randomized complete block design with the two irrigation treatments each replicated three times. A drip irrigation system was used for the crop irrigation.

Table1: Effect of different irrigation treatment with variable water parameter (Ground water and Treated wastewater)

Water parameter	Irrigation treatment		Significance
	GW	TW	
pH	7.63 ± 0.10	7.76 ± 0.09	ns
EC (dSm^{-1})	0.69 ± 0.05	2.18 ± 0.12	*
TSS ($mg\ l^{-1}$)	3.26 ± 0.34	16.21± 2.24	*
NH_4 -N ($mg\ l^{-1}$)	0.04 ± 0.00	0.39 ± 0.10	*
NO_3 -N ($mg\ l^{-1}$)	29.06±1.67	1.20 ± 0.23	*
NO_2 -N ($mg\ l^{-1}$)	0.02 ± 0.01	0.07 ± 0.02	*
PO_4 -P ($mg\ l^{-1}$)	0.10 ± 0.01	0.29 ± 0.02	*
BOD ($mg\ l^{-1}$)	9.33 ± 1.03	21.58± 1.62	*
COD ($mg\ l^{-1}$)	18.44 ±1.62	39.73± 2.78	*
Na^+ ($mg\ l^{-1}$)	33.53 ±0.54	219.85 ± 6.05	*
Ca_2^+ ($mg\ l^{-1}$)	52.82 ±3.23	85.27± 1.24	*
Mg_2^+ ($mg\ l^{-1}$)	8.90 ± 0.20	10.25± 0.12	*
K+ ($mg\ l^{-1}$)	9.35 ± 0.16	41.17± 1.96	*
$CO3^{2-}$ ($mg\ l^{-1}$)	171.50 ± 5.32	193.67 ± 11.89	ns
HCO^{3-} ($mg\ l^{-1}$)	257.89 ± 2.85	254.23 ± 21.57	ns
SO_4^- ($mg\ l^{-1}$)	30.17±1.30	31.84±0.85	ns
SAR	1.13 ± 0.03	5.99 ± 0.18	
Hardness ($mg\ l^{-1}$ CaCO3)	168.57 ± 7.79	255.20 ± 3.54	*

The above data revealed many interesting aspects: (i) the yields of the crop irrigated with Treated Water were not significantly different from those obtained when the crop was irrigated with Ground Water; (ii) for both the Ground Water and Treated Water irrigation treatments, the most important morpho-qualitative parameters of the processing crop (i.e., dry matter content, pH, soluble solid content, color parameters) were in agreement with those reported in the literature; and (iii) crops microbial quality was very good for all the literature stated, even when treated agro-industrial wastewaters were used. That was made possible by combining an accurate control of irrigation treatments with good agricultural practices [4].The present study focused on a comprehensive multidisciplinary approach for the assessment of product quality and safety during a single crop cycle, to evaluate the short-term effects on the use of Treated Water from the food industry. These facts are encouraging, if these could be used on wider basis i.e. on global basis [7]. Here some elements with its recommended maximum concentrations of trace elements in ppm with its remarks related to soil and plant through irrigation water is given below [5]:

Table 2.Recommended maximum concentrations of trace elements in irrigation water

Element	ppm	Remarks
Al (Aluminium)	5.00	Can cause non-productivity in acid soils (pH < 5.5), but more alkaline soils at pH > 7.0 will Precipitate the ion and eliminate any toxicity.
As (Arsenic)	0.10	Toxicity to plants varies widely, ranging from 12 mg/l for Sudan grass to less than 0.05 mg/l for rice.
Be (Beryllium)	0.10	Toxicity to plants varies widely, ranging from 5 mg/l for kale to 0.5 mg/l for bush beans.
Cd (Cadmium)	0.01	Toxic to beans, beets and turnips at concentrations as low as 0.1 mg/l in nutrient solutions. Conservativelimits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans.
Co (Cobalt)	0.05	Toxic to tomato plants at 0.1 mg/l in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Cr (Chromium)	0.10	Not generally recognized as an essential growth element. Con-servative limits recommended due to lack of knowledge on its toxicity to plants.
Cu (Copper)	0.20	Toxic to a number of plants at 0.1 to 1.0 mg/l in nutrient solutions.
F (Fluoride)	1.00	Inactivated by neutral and alkaline soils.
Fe (Iron)	5.00	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of availability of essential phosphorus and molybdenum. Overhead sprinkling may result in unsightly deposits on plants, equipment and buildings.
Li (Lithium)	2.5	Tolerated by most crops up to 5 mg/l; mobile in soil. Toxic to citrus at low concentrations (<0.075 mg/l). Acts similarly to boron.
Mn (Manganese)	0.20	Toxic to a number of crops at few-tenths to a few mg/l, but usually only in acid soils.
Mo (Molybdenum)	0.01	Not toxic to plants at normal concentrations in soil and water. Can be toxic to livestock if Forage is grown in soils with high concentrations of available molybdenum.
Ni (Nickel)	0.20	Toxic to a number of plants at 0.5 mg/l to 1.0 mg/l; reduced toxicity at neutral or alkaline pH.
Pd (Lead)	5.0	Can inhibit plant cell growth at very high concentrations.
Se (Selenium)	0.02	Toxic to plants at concentrations as low as 0.025 mg/l and toxic to livestock if forage is grown in soils with relatively high levels of added selenium. An essential element to animals but in very low concentrations.
Ti (Titanium)	----	Effectively excluded by plants; specific tolerance unknown.
V (Vanadium)	0.10	Toxic to many plants at relatively low concentrations.

Zn (Zinc)	2.00	Toxic to many plants at widely varying concentrations; reduced toxicity at pH > 6.0 and in fine textured or organic soils.

Facts about Wastewater:

1. Treated wastewater can also be a source of pathogenic organisms and potentially hazardous chemical substances, such as enteric bacteria and viruses, salts, heavy metals, and surfactants.
2. These wastewater then accumulate in the soils, with unfavourable effects on crop quality and productivity, and on the ecological soil conditions and one of the major concerns with wastewater re-use is the risk of the transfer of pathogenic microorganisms that represent a potential risk to human health if they enter the food chain.[12].
3. Many studies have shown that microbiological contamination can be a major issue for the re-use of treated agricultural wastewater. Thus to maximize the benefits and at the same time, to minimize the risks related to the use of treated wastewater, international policies should be adopted [10].
4. Studies showed that the agricultural use of reclaimed wastewater (municipal and agro-industrial) is retreated. With regard to microbiological contamination levels in particular, this decree has defined some significantly lower threshold values (e.g., *Escherichia coli*, <10 CFU 100 ml^{-1} in 80% of the samples) than those included in international guidelines [8].
5. These threshold values can be considered highly restrictive, because the risk of contamination has been reported to be low when contamination of irrigation water does not exceed 1000 CFU ml^{-1}.

Approaches towards Wastewater Treatment

Wastewater Treatment (Primary): Primary treatment is the initial treatment where influent is inflated and digested with the help of motor where it is squeezed and settling of effluent is done so that the disposal of semi solids and solids could be done.

Settling Tank: Settling tanks remove the large solids particles and remaining materials suspended in the wastewater and about 50 percent of the oxygen-demanding substances. The solids are sent on for further treatment (sludge digestion) and ultimate disposal.

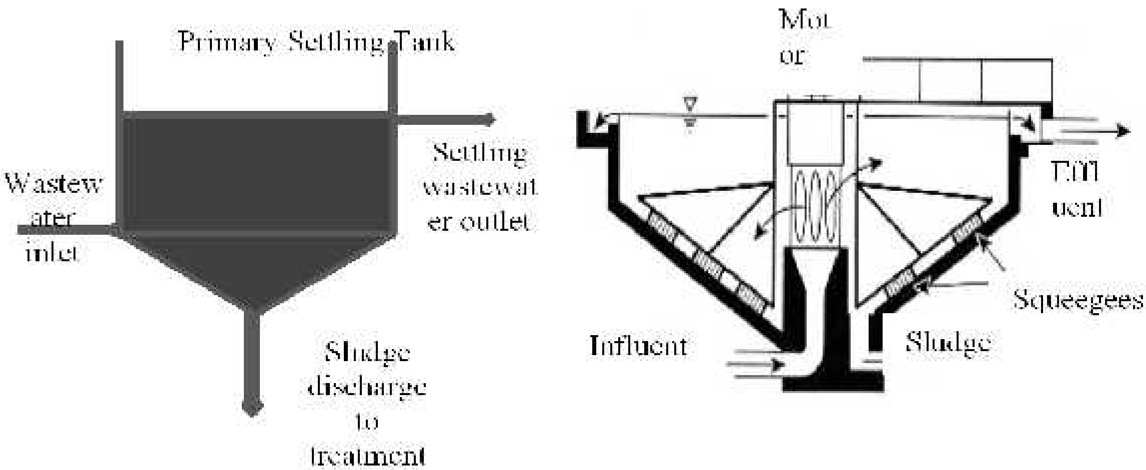

Fig1: Effluent discharge through primary settling tank.

Wastewater Treatment (Secondary): The secondary treatment includes the activated sludge process where it works on the principle of aerobic microbial inhibitor of solid waste, then settling of aerated effluent to Chamber where it get chlorinated and discharged through pump.

Activated Sludge: In the activated sludge process, bacteria and other microorganisms are used to remove small solids and oxygen-demanding substances present in the wastewater. Outflow from this tank undergoes settling and the excess sludge is sent on for further treatment (sludge digestion) and ultimate disposal. Carbon adsorption is an incredibly effective means of removing organic chemicals from wastewater. Chemicals which would otherwise pass through the plant and enter the environment. This technology is also applied in drinking water treatment, both municipally and with consumer-installed devices.

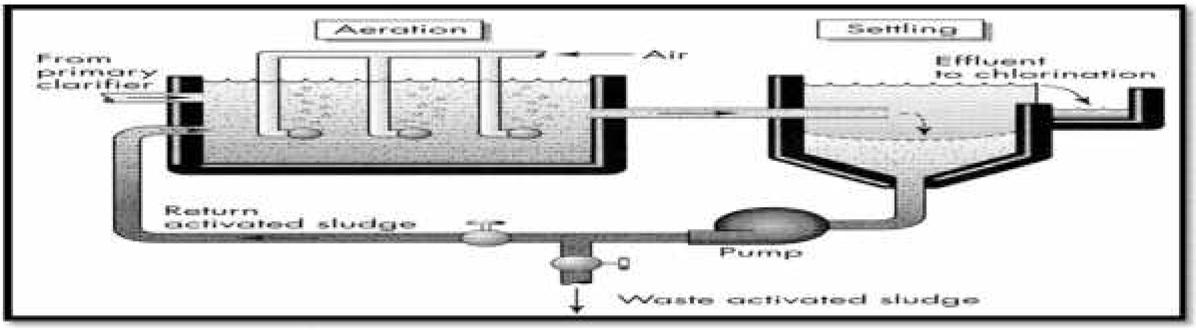

Fig2: Depicts the killing of solid based effluent through activated sludge.

Wastewater Treatment (Tertiary): The tertiary treatment of wastewater is highly effective as it includes disinfection through Ultraviolet Light (UV rays),the ultimate and potent source obtained from solar radiation and chlorine, which has a bleaching property helps in rectifying the wastewater and finally incineration of the solid waste is done by burning of the compound.

Disinfection: Disinfection is the most important step in wastewater treatment because it removes pathogens and thus protects receiving waters used for contact recreation and as a drinking water supply. Chlorine is the most commonly used disinfectant. Because of adverse effects on the environment, chlorine is being replaced by other methods such as ozonation and ultraviolet light. UV rays are extremely helpful in destroying of harmful microorganisms such as bacteria, fungi, some rotifers and other toxicants [9].

Incineration: A variety of means are available for ultimate disposal of sewage sludge. Land filling and incineration are the most common. Here, the sludge is introduced to the top of a multiple-hearth furnace. The sludge dries and ultimately ignites as it moves down the surface toward the fire. The product is ash (land filled) and stacks gases which are collected for further treatment.

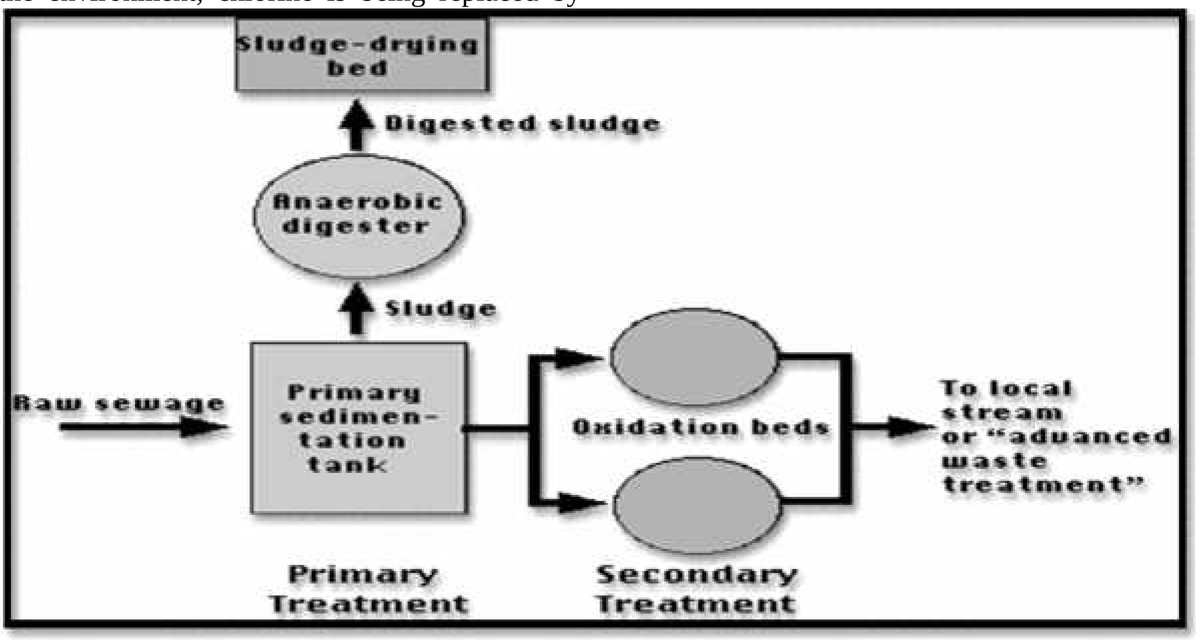

Fig 3:Incineration of raw sewage after primary and secondary treatment.

An experiment conducted to study effect of untreated and treated wastewaters on plant growth in pot culture, SAB Miller (ICRISAT, Hyderabad).Seed germination bioassay was conducted to assess the effects of wastewater on selected crops like chickpea, pigeon pea, cowpea, green gram, maize, pearl millet and sorghum also to evaluate the suitability of wastewater for irrigation purposes. Untreated (UASB outlet) and Treated (ETP Outlet) samples were collected from SAB Miller factory, Sangareddy, Andhra Pradesh. The effluent samples were analysed for Physico-chemical parameters. Different concentrations of effluent (50% & 100%) were prepared using distilled water and tap water was taken as control. The result was variable as shown in the below Table 3 [2].

Table 3. Effect of wastewater on seed germination, vigour index, radical length, and plumule length

Crop	Treatment	Control	ETP-50%	ETP-100%	UASB-50%	UASB
Maize	Germination (%)	100	100	87	90	83
	Vigour index	531	521	434	469	373
	Radical (cm)	3.84	3.46	3.41	3.72	3.04
	Plumule(cm)	1.47	1.75	1.58	1.5	1.46
Pigeonpea	Germination (%)	97	90	83	97	83
	Vigour index	822	575	387	746	314
	Radical (cm)	2.65	2.36	2.03	3.14	1.07
	Plumule (cm)	5.83	4.03	2.64	4.56	2.72
Chickpea	Germination (%)	93	97	80	97	83
	Vigour index	1521	1660	920	1710	873
	Radical (cm)	7.41	8.45	4.85	8.19	4.22
	Plumule (cm)	8.95	8.67	6.66	9.44	6.31
Sorghum	Germination (%)	87	67	70	70	60
	Vigour index	1175	647	417	772	394
	Radical (cm)	8.94	5.06	2.53	6.26	3.03
	Plumule (cm)	4.57	4.6	3.43	4.78	3.55
Pearl millet	Germination (%)	70	80	70	47	40
	Vigour index	973	797	223	317	100
	Radical (cm)	10.93	7.05	1.98	4.87	0.97
	Plumule (cm)	2.98	2.92	1.21	1.89	1.54
Greengram	Germination (%)	30	67	43	30	60
	Vigour index	182	582	266	73	427
	Radical (cm)	1.86	2.95	2.21	0.8	2.22
	Plumule (cm)	4.23	5.75	3.98	1.65	4.91
Mustard	Germination (%)	77	93	83	83	87
	Vigour index	985	1001	591	1402	786
	Radical (cm)	5.13	2.3	4.51	10.58	4.95
	Plumule (cm)	7.67	8.47	2.62	6.32	4.09
Cowpea	Germination (%)	80	43	70	77	60
	Vigour index	847	199	658	1680	624
	Radical (cm)	5.46	2.74	4.9	11.25	5.46
	Plumule (cm)	5.13	1.89	4.51	10.58	4.95

Other Relevant Waste Water Treatment Technologies: The advantage of wastewater treatment using these technologies is that they can reduce the organic and inorganic loads, increase dissolved oxygen levels, mitigate CO_2 pollution and generate valuable biomass by sequential use of heterotrophic and autotrophic algal species and the generated biomass can be an excellent source of ‘organic’ fertilizers. As documented in studies on eutrophication, they are known to thrive under very high concentrations of inorganic nitrates and phosphates that are otherwise toxic to other organisms. This particular aspect of filtration can help remediate highly polluted wastewaters.

- Bioremediation
- Coagulation/Floc
- Membrane filtration
- Filtration/gravity
- Oxidation/Ozone
- Thermal Oxidation
- Encapsulation
- Evaporation

Tests related to Water Treatment: Wastewater is more saline due to dissolved solids originating in urban areas, and concentrated further through high evaporation in arid and tropical climates. Due to wastewater used in agriculture may cause salinity problem and can decline the land productivity. Excessive industrial release to the environment can lead to a buildup of toxic pollutants, which can in turn encourage the overgrowth of weeds, algae, and cyanobacteria and deteriorate groundwater and downstream water quality. Some useful tests related to physical and chemical analysis of wastewater are given below:

Physical Tests for Water Quality

1. Water in settling tanks removes sand, silt and clay (by adding chemicals may help clump particles)
2. Clearwater flows over the activated charcoal, gravel and sand filters
3. Ammonium Chloride may be added to kill pathogens

Chemical Tests for Water Quality

1. Temperature: affects D.O. higher the temp., less will be D.O.
2. pH: Measures if water is acidic or basic–most living things need to be near neutral
3. Conductivity: Measures the dissolved ions in the water, not what is there, but how much.
4. Dissolved Oxygen (D.O.): Measures the amount in ppm–best if around 8–12 ppm for most living thing.
5. Turbidity: Measures amount of suspended particles – streams usually turbid after heavy

rains, but clear up as water slows down. Good for ponds and lakes.

Conclusion: As mentioned above, wastewater is reclaimed by any of these techniques including certain tests which would be beneficial not only in terms of agriculture practices which reduces the extra burden on water and improving the quality of water which is a wastewater but also it increases the soil fertility. The treated wastewater also enriched the soil through certain important micronutrients. It acts as an amendment of soil with irrigation water supplemented on it. With the destruction of its toxicants and harmful bacteria's, it can safe for human use also.

Future Prospects: In developing countries like India, the problems associated with wastewater reuse arise from its lack of treatment. The challenge thus is to find such low-cost, low-tech, user friendly methods, which on one hand avoid threatening our substantial wastewater dependent livelihoods and on the other hand protect degradation of our valuable natural resources. The use of constructed wetlands is now being recognized as an efficient technology for wastewater treatment. Further these systems have lower construction, maintenance and operation costs as these are driven by natural energies of sun, wind, soil, microorganisms, plants and animals. Hence, for planned, strategic, safe and sustainable use of wastewaters there seems to be a need for policy decisions and coherent programs encompassing low-cost decentralized waste water treatment technologies, bio-filters, efficient microbial strains, and organic / inorganic amendments, appropriate crops/ cropping systems, cultivation of remunerative non-edible crops and modern sewage water application methods. In this context, a consortium of research institutes and industries will help in identifying efficient wastewater utilizing and treatment methodologies. This co-creation process will boost the sustainable development in the field of bio-treatment, wastewater re-use, and agricultural innovations to reduce the water footprint.

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