Food Industry Wastewater Treatment by Constructed Wetlands

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ABSTRACT

Wastewater is always going to remain issue until new technologies does not involve in it. The point of treating wastewater by conventional system is that it's easy and costly but is it sustainable? The coal is used to generate electricity that runs the motor that treats the wastewater but what is new in that, we know that sustainability is the only solution this days. As it has been estimated that most of the developing countries will run out of water by 2050 and scientist will have to encourage in finding the new technologies and that is possible only when we use what we have rather than invest in impossible. Constructed wetlands systems as we know uses land that is available and plants of specific types and season wise for specific wastewater to treat it. Firstly they have been used for urban and domestic wastewater treatment, but in the last two decades, the applications for industrial wastewater treatment increased due to the evolution of the technology and the experimented research on the field. Nowadays, Constructed wetlands have been applied to the treatment of different kind of effluents as such as refinery and petrochemical industry effluents, food industry effluents including dairy waste, waste from meat and flash, fruit and vegetables processing industries, distillery and winery effluents, pulp and paper, textile, tannery, aquaculture, steel and mixed industrial effluents. Constructed wetlands and its types are important factor as different wastewater is treated differently for removal of nutrients, organic matter, suspended solids and that is to be discussed in briefly here.

Key Words *:* Industrial wastewater, constructed wetlands, Nutrients removal, COD, TDS.

Introduction :

The introduction refers to the use of constructed wetlands (CWs) for industrial wastewater treatment and their efficiency for nutrient removal. Constructed wetlands are engineered systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soils, and their associated microbial assemblages to achieve wastewater treatment (Vymazal, 2014).

"Modern treatment wetlands are man-made systems that have been designed to emphasize specific characteristics of wetland ecosystems for improved treatment capacity" (Kadlec & Wallace, 2009). Constructed and engineered wetlands can cover a broad range of objectives such as improving biodiversity and environmental conditions related to, wildlife use, irrigation of agriculture lands and improving river water quality. As Constructed wetlands have evolved with time and applications, other terms like engineered wetlands have appeared that might include the use of devices that upgrade the performance using energy input. CWs are low-cost and ecofriendly technologies, that take advantage of natural processes to remove pollutants from the water, generally avoiding the use of chemical products and the input of high amounts of external energy. On the other hand, CWs may require a large surface, which is its major drawback. As a result; they are included in the group of extensive technologies for wastewater treatment. The first research into CWs for wastewater treatment took place in Germany, in the 1950s (e.g., Seidel, 1961), with special focus on phenols removal. From the beginning, the first applications of CWs dealt with urban wastewater, but in the last two or three decades, they have been applied for industrial and agricultural wastewater, as well as stormwater runoff and the treatment of landfill leachates (Vymazal 2011a).

Working of constructed wetland and their types :

Pollutant removal in natural wetlands takes place due to the combination of physical, chemical and microbial processes. The processes involved in pollutant removal are sedimentation, sorption, precipitation, evapotranspiration, volatilization, photodegradation, diffusion, plant uptake, and microbial degradation (for instance, nitrification, denitrification, sulphate reduction, carbon metabolization, etc.) among others.

Wetlands :

A wetland is a land area that is saturated with water , either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem. The primary factor that distinguishes wetlands from other land forms or water bodies is the characteristic vegetation of aquatic plants, adapted to the unique hydraulic soil.

There are two types of wetlands: Natural & Constructed.

Natural Wetlands : Natural wetland systems have often been described as the "earth's kidneys" because they filter pollutants from water that flows through on its way to receiving lakes , streams and oceans. There are four main kinds of wetlands – marsh, swamp, bog and fen (bogs and fens being types of mires). Some experts also recognize wet meadows and aquatic ecosystems as additional wetland types.

Constructed Wetlands : Constructed wetlands are artificial wastewater treatment systems consisting of shallow (usually less than 1 m deep) ponds or channels which have been planted with aquatic plants, and which rely upon natural microbial, biological, physical and chemical processes to treat wastewater. They typically have impervious clay or synthetic liners, and engineered structures to control the flow direction, liquid detention time and water level. By various such process chemicals are considerably removed or settled and clean water is drawn. These chemicals include Nitrogen, Ammonia, Phosphorous and pathogens. Constructed wetlands are most economical as compared to conventional treatment units which needs more energy for its process and this method require cheaper materials.

Types of constructed wetlands :

Constructed wetlands are classified into two types:

1. Surface flow constructed wetlands and
2. Subsurface flow constructed wetlands : Horizontal flow, Vertical flow

Surface flow : Surface flow wetlands, also known as free water surface constructed wetlands, can be used for tertiary treatment or polishing of effluent from wastewater treatment plants. They are also suitable to treat storm water drainage. Surface flow constructed wetlands always have horizontal flow of wastewater across the roots of the plants, rather than vertical flow. They require a relatively large area to purify water compared to subsurface flow constructed wetlands and may have increased smell and lower performance in winter.

Subsurface flow : In subsurface flow constructed wetlands the flow of wastewater occurs between the roots of the plants and there is no water surfacing. Subsurface flow wetlands can be further classified as horizontal flow or vertical flow constructed wetlands. In the vertical flow constructed wetland, the effluent moves vertically from the planted layer down through the substrate and out (requiring air pumps to aerate the bed).In the horizontal flow constructed wetland the effluent moves horizontally via gravity, parallel to the surface.

1. **Horizontal Subsurface Flow Constructed Wetland :** A horizontal subsurface flow constructed wetland is a large gravel and sand-filled basin that is planted with wetland vegetation. As wastewater flows horizontally through the basin, the filter material filters out particles and microorganisms degrade the organics. The horizontal subsurface flow constructed wetland is a good option where land is cheap and available. Depending on the volume of the water and the corresponding area requirement of the wetland, it can be appropriate for small sections of urban areas, as well as for semi-urban and rural communities. It can also be designed for single households.
2. **Vertical Subsurface Flow Constructed Wetland :** A vertical flow constructed wetland is a planted filter bed that is drained at the bottom. Wastewater is poured or dosed onto the surface from above using a mechanical dosing system. The water flows vertically down through the filter matrix to the bottom of the basin where it is collected in a drainage pipe. The important difference between a vertical and horizontal wetland is not simply the direction of the flow path, but rather the aerobic conditions. The vertical flow constructed wetland is a good treatment for communities that have primary treatment (e.g., Septic Tanks) but are looking to achieve a higher quality effluent. Because of the mechanical dosing system, this technology is most appropriate where trained maintenance staff, constant power supply, and spare parts are available. Since vertical flow constructed wetlands are able to nitrify, they can be an appropriate technology in the treatment process for wastewater with high ammonium concentration.

Methodology :

Constructed wetland for food industry wastewater that of pickle industry was carried out in a 2 different plastic tubs that of capacity 20 Liters of which depth is 13 inch, width 13 inch and 26 inch radius. Pickle industry wastewater was taken 55L. The constructed wetland was followed by 1st layer clay, the plants of 2 different types Hydrilla and Eichhornia were nurtured in water from gomti pond rather then directly planting in wastewater so that they don't burn but grow and live easily and then it was exchanged by wastewater for a week to make them grow in comfortable environment and which was followed after a week shifting directly to wastewater itself.

Wastewater Characteristics :

The parameters taken in consideration for wastewater treatment for process in effluents were high in concentration by values of pH 6-7, high COD values (6200- 6600mg/L), high BOD values (900-950mg/L) and high TDS (6000-7000mg/L). The nutrients values as following Potassium (K) 150 ppm, Nitrate 60ppm, Nitrite 65ppm, phosphate 16ppm. These characteristics makes Constructed wetland the premium for the food processing effluent treatment. A summary of the characteristics of the wastewater are shown in following Table.

Parameter	Values (ppm)
Odour	Foul
pH	6.18
BOD	903
COD	6511
TDS	6922
Potassium	150
Nitrate	60
Nitrite	65
Phosphate	15

Experimental Setup :

The arrangement was made up of two tubs containing the Food industry (Pickle) wastewater each of 15 liters, the plants were arranged in the vertical form and was kept for 10 days interval for 1st time and then for 15 days (i.e 25 days) interval for same plants and the wastewater was added 10 liters in each of the tub and then 5 liters wastewater was added in each tub at 21 days (i.e 32 days) in total. The purpose of adding water was that plants don't dry up now, as the seasonal variations were observed due to summer at the end the wastewater and plants dried up at overall 40 days because no additional wastewater was added afterwards and residue was sun dried and was asked to spread up in local public garden as manure.

The results of 10 days, 25 days and 32 days were calculated and when observed there was drastic drop of TDS, BOD, COD, pH and Nutrients were observed, which seems to suggest how constructed wetlands are accepted along with conventional system or given time might even replace conventional system.

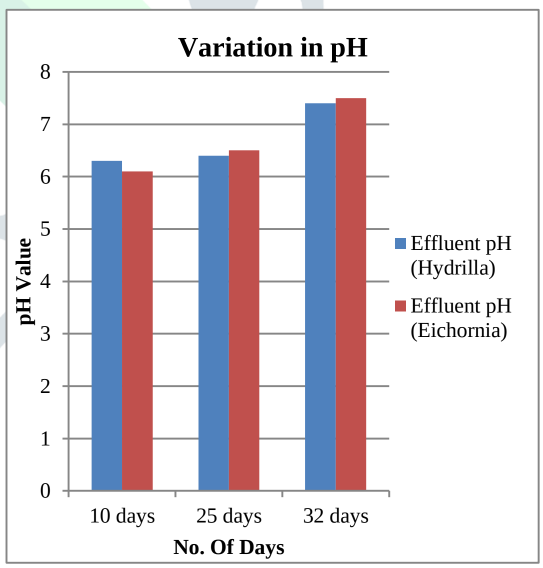
Results and observations:

The results of wastewater were carried out as following :

pH observation:

No considerable variations were observed between treated wastewater and untreated food processing wastewater. The graph shows an increase in pH of effluent but within limit.

No. of days	Effluent pH (Hydrilla)	Effluent pH (Eichornia)
10 days	6.3	6.1
25 days	6.4	6.5
32 days	7.4	7.5



BOD :

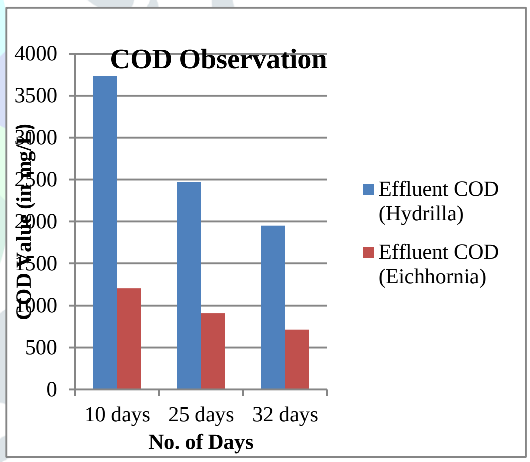
Biochemical oxygen demand (BOD_5) is a measure of the oxygen consumption of microorganisms in the oxidation of organic matter. Settleable organics are rapidly removed in experimental system by quiescent conditions, deposition, and filtration. Attached and suspended microbial growth is responsible for removal of soluble BOD_5. It was observed that removal of BOD is mainly in first 10 days of each Experimental Run, after that the removal is at a slower rate. It is mainly due to plant update is much high in first 10 days similarly significant plant growth was observed during this period as well. The maximum BOD removal was in Eichhornia with 87.8% and results of Hydrilla for 10 days, 25 days and 32 days are 63.4%, 70.98%, 79.84% and that of Eichhornia is 76.4%, 81.5% and 87.8%.

No. of days	Effluent BOD (Hydrilla)	Effluent BOD (Eichhornia)
10 days	330	213
25 days	262	167
32 days	182	112

COD

COD is the amount of oxygen necessary to oxidize the Organic Compound (OC) completely to CO_2, H_2O and NH_3 The overall decrease in COD was observed due the results confirmed by the growth of Hydrilla and showed high performance to remove COD mainly because of well-developed root system. Similarly it was observed that a major part of the degradation of COD in the wastewater is attributed to micro-organisms which may have established a symbiotic relationship with the plants. The maximum COD removal was from Eichhornia at 89% and that of hydrilla for 10 days, 25 days and 32 days are 42.69%, 62.6% and 70.5% and that of Eichhornia is 81.5%, 86% and 89%.

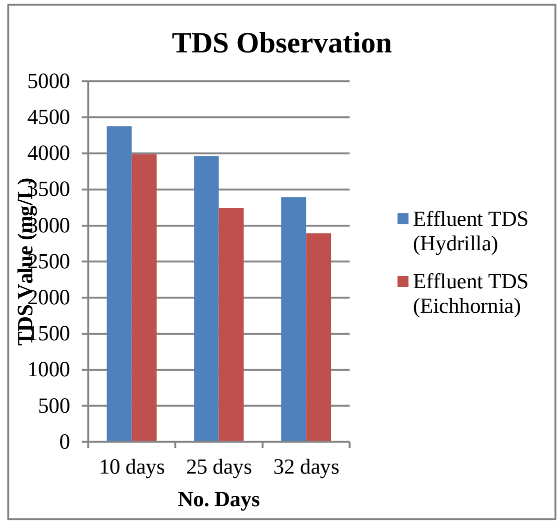
No. of days	Effluent COD (Hydrilla)	Effluent COD (Eichhornia)
10 days	3731	1203
25 days	2470	906
32 days	1950	713



TDS:

It is quite clear that TDS will be accumulated in the stems of plants are the dissolved particles are gonna degrade easily in the process which results in decreased TDS concentrations. The maximum TDS reduction in constructed wetlands is about 58% from Eichhornia plant. The percentage reduction in TDS for 10 days, 25 days and 32 days for hydrilla is 36%, 42% and 51% and for eichhornia is 43%, 54% and 58%.

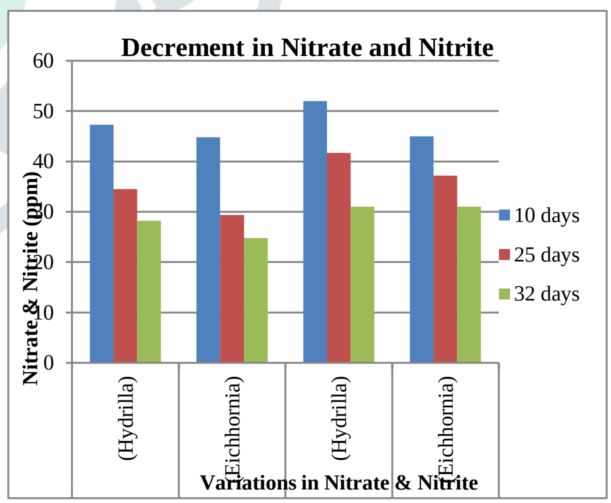
No. of days	Effluent TDS (Hydrilla)	Effluent TDS (Eichhornia)
10 days	4378	3987
25 days	3965	3246
32 days	3392	2890



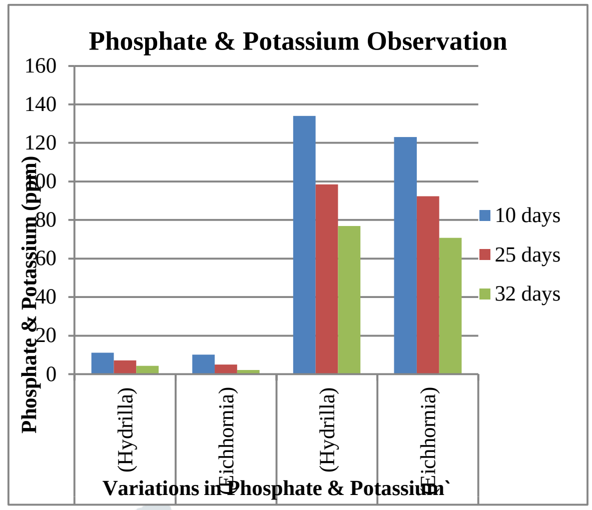
Nutrients (N,P,K):

It has been observed that the greater ratio of plant model the volume and can enhance the contact between plant roots and wastewater resulting in a greater nutrient removal. Plants and micro-organisms all utilize P as an essential nutrient, and contain P in their tissues though the portion of tissue P is very small compared with K and N. Highest Nitrate removal was at 32 days with 58.6% and for Hydrilla plant at 10 days, 25 and 32 days was 21%, 42.5% and 53% and for Eichhornia plant for 10 days, 25 and 32 days is 25.3%, 51% and 58.6% removal. Nitrite removal was observed maximum for Eichhornia at 32 days at 52.3% and for Hydrilla at 10 days, 25 and 32 days is 20%, 35.8% and 48% and for Eichhornia at 10 days, 25 and 32 days is 30.8%, 42.76% and 52.3%. For, Potassium (K) the highest removal was at 32 days at Eichhornia of 52.8% and for Hydrilla at 10 days, 25 and 32 days is 10.6%, 34.3% and 48.7% removal and for Eichhornia for 10 days, 25 and 32 days is 18%, 38.4% and 52.8%. Now, for Phospahte the highest removal is 85.6% for Eichhornia and for Hydrilla at 10 days, 25 and 32 days is 25.3%, 52% and 71.8% and for Eichhornia at 10days, 25 and 32 days is 32.2%, 66.66% and 85.6% removal.

No. of days	Nitrate (Hydrilla)	Nitrate (Eichhornia)	Nitrite (Hydrilla)	Nitrite (Eichhornia)
10 days	47.3	44.8	52	45
25 days	34.5	29.4	41.7	37.2
32 days	28.2	24.8	31	31



No. of days	Phosphate (Hydrilla)	Phosphate (Eichhornia)	Potassium (Hydrilla)	Potassium (Eichhornia)
10 days	11.2	10.17	134	123
25 days	7.2	05	98.5	92.3
32 days	4.3	2.16	76.9	70.7



Conclusion :

The experiment results shows how it becomes easy for food industry wastewater to treat by constructed wetlands. The wetlands are highly valued for providing protection against pollution to water resources such as lakes, estuaries and groundwater. The best results in constructed wetlands are derived when the systems are combined and made hybrid. Results shows that the constructed wetlands shows the highest reduction rate in BOD, COD , TDS and NPK by 87%, 89%, 58% 58.6% (Nitrate), 52.3% (Nitrite), 52.8% (K) and 85.6% (Phosphate) for Eichhornia at 32 days time period. The Residue formed was sun dried and was asked to spread in local public garden as manure.

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