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Biodegradation and Bioremediation of Food Industry Waste Effluents

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ABSTRACT: In the present study, impact of wastewater emanated from 5 Star hotel were subjected to treatment using activated charcoal and the treated water was subjected to seed germination and some physiological parameters of *T. foenum* were studied. Use of treated water for irrigation purposes has emerged an important way to utilize its nutrients and removal of its pollution load by growing tolerant plant species. The effect of waste water on seedling was significant at various concentrations. Further the difference in seedling vigour index also showed a similar trend of statistical significance with treatment at different concentrations. Germination efficiency, seedling length and seedling vigour index, was found to be increased with increase in concentration of waste water up to 50% dilution after which it decreases. Thus, the waste water, after proper dilution can be used as a potential source of water for seed germination and plant growth in agricultural species.

KEYWORDS: Wastewater, Physiological parameters, Seed Germination, Plant growth.

I. INTRODUCTION

In general, food wastes can be successfully used as feedstock of compost. Water contains a variety of physical, chemical and biological substances, which are either dissolved or suspended in it. The untreated effluent water usually contains numerous pathogenic micro organisms and nutrients that can stimulate the growth of aquatic plants Effluent components are much higher than the WHO and ISI prescribed permissible limits. So the industrial effluent are completely treated, and then discharged into sewage or land. The present work is undertaken with a view to study the nature of effluents from food waste. Wastewater treatment is closely related to the standards (water node 83330) and / or expectations set for the effluent quality. Wastewater treatment processes are designed to achieve improvements in the quality of the wastewater Prabhakar et al [7]. Water is one of the most important precious resources found on the earth. The water resources are most often affected by anthropogenic activities and also from industries. Growth of population, massive urbanization, rapid rate of industrialization and modern techniques in agriculture have accelerated the water pollution and led to gradual deterioration of its quality. Due to continuous disposal of waste water into the water bodies, surface water quality throughout the country has deteriorated because of the mixing of various chemical pollutants of the effluent with water. This effluent contains various micro nutrients essential for growth of crop plant. However, many industrial wastes may have harmful effects and may cause soil fatigue Prabhakar et al [7]. The major source of contamination is the continuous disposal of wastewaters released from manufacturing industries into the environment. The industries use water as a raw material, heating or cooling medium, carrier for raw material and solvent. It should be noted that only a small fraction of supplied water is present in the end product, the rest are let out as wastewater. This contains unutilized raw materials, products and by products. The amount of such materials present mainly depends on the nature of the process employed. These wastewaters can be disposed safely after the attainment of permitted level of contamination. When the permitted level of contamination is exceeded significantly, the characteristics of natural resources will be affected severely. The main problem stems from the waste coming from process industries due to their large volume and degree of variation. Often industrial wastewaters are either discharged directly into the surface water bodies or else into the municipal sewers. The presence of contaminants in water causes diseases and makes water unfit for human consumption. Industrial wastewaters contain a variety of re calcitrant organic compounds which are toxic, carcinogenic and mutagenic in nature. Most of the recalcitrant compounds contain one or more aromatic rings which are generally resistant to biological treatment. All these compounds are highly persistent in the environment and have the potential to produce negative impacts to flora and fauna. The effluents released from textile, leather, paper, plastics, etc., contain various kinds of synthetic dyestuffs. On the other hand, effluents released from pharmaceutical industries contain proteins, antibiotics, endocrine disrupting compounds, etc. Over 100 pharmaceuticals are known to be present in water up to the level of microgram per litre Rodayan et al [9]. Food industry is one of the most resource-demanding branches of industry; therefore it is especially important to ensure rational usage of raw materials. In the processing sub-branches of agricultural complex where the net value of products is comprised of material and energy expenditures, it is increasingly crucial to decrease the consumption of materials. This can be achieved by dint of wide implementation of non-waste technologies, complex usage of raw materials and secondary (recycled) resources in combined industry. Another important aspect of the subject problem is ensuring of ecological safety of plants where the food products are produced as well as elimination of the influence of the wastes upon the environment. One of the most important problems which the food industry enterprises face is the problem of wastewater treatment. Daily, large quantities of industrial effluents are discharged, virtually untreated into the rivers. An estimated 80% of industrial effluents flow directly into the rivers through ditches, shallow pits, gutters and trenches. Some of the pollutants encountered in municipal borne water supply originate from industrial effluents which are deliberately produced and released into water bodies. Industrial effluent is known to contain contaminants and its disposal to water bodies without proper treatment may results to exposure of humans to such contaminants. With increasing scarcity of treated public water supply, fresh river water has become the alternative source for drinking. The World Health Organisation (WHO) recognizes the need to ensure the safety of most water bodies that serve as sources of drinking water supplies to the public. Hence routine monitoring of water quality of such useful water bodies is expedient as required by WHO Scheren et al [10]. Although the food and beverage industries are not as polluting as some other sectors like metal or leather industries, they have been responsible for air, water and soil pollution by emitting dust and unpleasant odour in the air, discharging liquid effluent with high organic content and generating large quantities of sludge and solid waste. Some potato starch processing companies produce 100,000 to 250,000 m^3 of starch-containing sludge annually. Wastewater is the primary area of concern at the food and beverage industry. With the exception of some toxic cleaning products, wastewater from food-processing facilities is organic and can be treated by conventional biological technologies. Primary issues associated with food and beverage industrial wastewater are biochemical oxygen demand (BOD); chemical oxygen demand (COD); total suspended solids (TSS); excessive nutrient loading viz. nitrogen and phosphorus compounds; pH of the water; total alkalinity and pathogenic organisms. Solid wastes from the food and beverage industries include both organic and packaging waste. Organic wastes from raw materials such as food grain, flavouring and colouring agents result out from processing operations. Inorganic waste typically includes excessive packaging items like plastic, glass, and metal. If the effluents from the food and beverage industry are contaminated with toxic metals, these can affect adversely on human health as either acute or chronic diseases. Livestock and agricultural production around the industry and its disposal site can also be hampered. Many industrial organic substances found in water can cause death or reproductive failure in fish, shellfish and wildlife. In addition, they can accumulate in animal and fish tissue, be absorbed in sediments, or find their way into drinking water supplies, posing long-term health risks to human. The presence of coli form bacteria indicates that there is a high probability of other pathogenic organisms present. When water is contaminated with a surface drainage, non-coli form bacteria may also be present in large numbers. The avoidance of waste formation and pollution is always a key task. But on the other hand, waste prevention, recycling, minimization & valorisation; and the use of energy efficient process technologies are more and more desirable options in waste management Robinson et al [8]. The effluent treatment technologies can broadly be classified as biological, physical and chemical processes. Due to disposal problems and high cost involved, many of these processes cannot be adopted for large scale industrial applications. The complex nature of the industrial effluents made any single process incapable thereby it necessitated to employ more than one process for the complete degradation. So, currently combination of different treatment processes are proposed, many of which are implemented in large scale, to produce desired high quality treated effluent in a most economical way Ghodbane and Haghighi, [3]. The conventional physical methods used to improve or upgrade the quality of wastewater include sedimentation, screening, aeration, filtration, degasification, equalization, etc. Nowadays, more attention has been paid towards membrane operations, in which pressure driven operations such as microfiltration, ultra filtration, nano filtration, reverse osmosis, gas separation, evaporation are used. Similarly, the concentration driven membrane operations include dialysis, osmosis, forward osmosis and membrane operations using electric potential gradient, such as, electro dialysis, membrane electrolysis and electrophoresis, also attracted the research community. Chemical methods employed to treat industrial wastewater include coagulation or flocculation combined with floatation and

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filtration, precipitation flocculation with $Fe(II)/Ca(OH)_2$, electro floatation, conventional oxidation using oxidizing agents such as hydrogen peroxide, ozone, etc., irradiation or electrochemical methods. These chemical processes are more efficient and fast on degrading the industrial effluents. But high cost involved and generation of concentrated sludge, which in turn is difficult to dispose, are the major drawbacks on using chemical methods to treat wastewaters. Many of these processes generate secondary pollutants due to the use of excessive chemicals. Compared to physical and chemical processes, biological process was found to be most economical and also efficient. Most frequently used biological processes include fungal degradation, microbial degradation, adsorption on living or dead biomass and bioremediation. Many microorganisms such as bacteria, fungi, yeast etc are found to be more capable to accumulate and degrade the pollutants in an effective way. But their application has been restricted significantly due to technical constraints. Requirement of large area, sensitivity towards operating parameters, toxicity of the chemicals present or used and less flexibility in design and operation made biological treatment less attractive. Further, they are incapable of producing desired quality of treated effluent using current conventional biological processes. This is due to the fact that, even though many organic pollutants can be degraded biologically, many others cannot be treated as they are either recalcitrant in nature or of synthetic origin Robinson et al [8]. The present study to investigate the physico-chemical analysis of food waste effluents in treated and untreated effluents by the germination of seeds.

II. MATERIALS AND METHODS

A. Sulphate

Take 150 ml sample was taken in beaker and make it acidic with HCl. The solution was heated to boiling point and add to it Barium chloride solution, slowly with stirring. Add this till precipitation is complete. The precipitate was digested to 90^0 C for 2 hours. The solution was filtered through filter paper. The precipitate was washed with warm distilled water, till wash water is free from chlorides by using $AgNO_3$ solution, till there is no colour change. The filter paper was dried and precipitated to 750^0C in muffle furnace for 30 minutes. It was cooled and weighed the precipitate with crucible.

$$\textit{Sulphates in } mg/L = \frac{\textit{residue wt}(mg) \times 411.5(\textit{Molecular wt of } BaSO4}{\textit{Sample weight }(ml)} \times 1000$$

B. Chlorides (mohr's method)

50ml of sample was taken in conical flask. 3 drops of $K_2Cr_2O_4$ indicator was added. In burette N/35.45 $AgNO_3$ Solution was taken. It was titrated till the colour changes from yellowish to reddish brown stable precipitate.

$$\textit{Chlorides in sample} = \frac{\textit{Burette reading}}{\textit{Sample Volume }(ml)} \times 1000$$

C. Total Dissolved Solids

A known quantity of liquid sample was taken in a crucible of known weight. The sample was filtered through Whatmann paper No.44. The unfilterable solids remain on the filter paper while dissolved solids go in solution through the filter paper. The known quantity of the filtered solution was taken in a crucible of known weight and dry it to a temperature of 103^oC-105^oC.It was cooled the crucible and weighed with residue.

$$\textit{Total dissolved solids in } mg/L = \frac{W2-W1}{\textit{Sample weight }(ml)} \times 1000$$

(W_1)= Weight of empty crucible

(W_2)= Weight of crucible after heating

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D. Total Suspended Solids

The empty crucible was taken and cleaned it thoroughly, made it perfectly dry. The weight of the empty crucible was taken (W_1 g). The crucible was added to 25ml of liquid sample. The crucible was heated till the entire liquid in the crucible evaporates and dry residue remains at the bottom. The weight of the crucible was taken with residue after cooling for 20 minutes. Weight (W_2 g). The same crucible was taken and kept it in muffle furnace at a temperature of 650 ^{o}C for 30 minutes. During this time the volatile and organic matter in the solids is evaporated. What remains in the crucible is “Fixed solids”. It was cooled and weighed it with the fixed solids residue (W_3 g).

E. Biological Oxygen Demand in Water (BOD)

Pure water was taken in glass container (about 5 litres) and bubble compressed air for Day to attain saturation. 1 ml each of manganese sulphate, phosphate buffer, and ferric chloride and calcium chloride solution was added for each litre of distilled water. If the waste water is not expected to contain sufficient bacteria population, add seed to dilution water. [Generally 2 l of settled sewage for 1000ml of water] Neutralized the sample of pH 7.0. The dilution of the sample are made such that about 50% depletion of DO takes place and residual DO after incubation for 5 days is not less than 1 mg/lit. 6 BOD bottle was taken prepared 2 bottles blank, for determination of initial DO. In 2 bottles necessary diluted sample was added. Kept 2 blank. Kept 4 bottles in incubator at 20^o C for 5 days. 1 bottle and one sample bottle was taken and determined its initial DO contents by adding manganese sulphate, alkaline iodide azide agent and conc. H_2SO_4 and titrate. The same was done with 0.025 N sodium thiosulphate solution using starch as indicator. Noted the burette reading. After 5 days DO was determined in the incubator bottles (blank and with sample) in the similar ways.

$$BOD\ (mg/L) = (D_O - D_1) - (C_O - C_1) \times 100$$

D_O = DO of sample on-0th day

D_1 = DO of the sample on 5th day

Co = DO of Blank on-0th day

C_1 = DO of the Blank on 5th day

F. Chemical Oxygen Demand in Water (COD)

Three COD vials were taken with stopper (two for the sample and one for the blank). 2.5ml of the sample were added to each of the two COD vials and the remaining COD vial is for blank; to this COD vial add distilled water. 1.5ml of potassium dichromate reagent – digestion solution was added to each of the three COD vials. 3.5ml of sulphuric acid reagent – catalyst solution was added in the same manner. Capped tubes tightly. Switched on the COD digester and fixed the temperature at 150^{o}C and heated for 2 hours. The COD vials were placed into a block digester at 150^{o}C and heated for 2 hours. The digester automatically switches off. Then removed the vials and allow it to the room temperature. Mean while, got ready with the burette for the titration. The burette was filled with the ferrous ammonium sulphate solution, adjusted to zero and fix the burette to the stand. The content of the blank vial was adjusted. Few drops of ferrion indicator were added. The solution becomes bluish green in colour. It was titrated with the ferrous ammonium sulphate taken in the burette. End point of the titration is the appearance of the reddish brown colour. Noted down the volume of ferrous ammonium sulphate solution added for the blank (A). Transferred the content of the sample vial to conical flask. Few drops of ferrion indicator were added. The solution becomes green in colour. It was titrated with the ferrous ammonium sulphate taken in the burette. End point of the titration is the appearance of the reddish brown colour. Noted down the volume of ferrous ammonium sulphate solution added for the sample (B).

$$COD = \frac{(A - B) * N * 8 * 1000}{Volume\ of\ sample\ taken}$$

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G. pH

The pH meter was switched on. Electrodes from storage solution was removed and rinsed with water. Bloated with soaked tissue paper. The instrument was standardized with electrodes immersed in a buffer solution (Acetate buffer pH = 4). Rinsed, bloated and dried the electrodes to each tie. The pH was checked in the pH meter (pH = 7). The pH electrode was dipped in the beaker containing waste water to be tested. Then the pH was noted.

H. Seed Germination Studies

In this experiment, the effect of effluent was evaluated on germination of seeds of 1 plant, *Trigonella foenum*. The seed were germinated in fertile soil. Each seed were pre-treated with treated and untreated effluents collected from food industries. Seeds germinated using with distilled water was used as a control. Plants were allowed to grow for the period of 4 to 6 days. Germination of seeds was daily recorded. At the end of the germination experiment, the shoot and root length of seedlings was measured.
The root length and shoot length of the germinated seeds were measured from each experimental set. The shoot length was measured from the base of the primary leaf to the base of the hypocotyls and the mean shoot length was expressed in centimetre. Root length was measured from the tip of the primary root to the base of hypocotyls and mean root length was expressed in centimetre. By adding the root length and shoot length, seedling length was calculated and expressed in centimetre.
The number of seeds germinated in each treatment was counted on every day after sowing and the germination percentage was calculated by using the following formula.

$$\textbf{Germination } \% = \frac{\textbf{No. of seeds germinated}}{\textbf{Total No. seeds sown}} \times \textbf{100}$$

III. EXPERIMENTAL RESULTS AND DISCUSSION

In the present investigation the pH value of treated and untreated were recorded as 6.20and 6.80 units respectively. According TNPCB standards the pH of the effluents should be in range 5.5 - 9.0 units. In the present investigation the total solids in untreated effluent was 900 mg/L and 500 mg/L in treated effluent. In both the samples in TDS values are much higher compared to TNPCB Standard (2100 mg/L). According to this investigation the suspended solids of untreated effluent were 950 mg/L and 150 mg/L respectively. In both the samples in TDS values are much higher compared to TNPCB Standard (200 mg/L). In the present investigation sulphate in untreated effluent was 1250 mg/L and treated effluent was recorded 761 mg/L according TNPCB standard the sulphate should not exceed the 1000 mg/L. High SO_4 amount in both the effluents is attributed to the use of sulphur during crystallization. The presence of chloride in natural water is attributed to dissolution of salt deposit, discharge of effluents from chemical industries oil well operations. In the present study chlorides of untreated was 524 mg/L and in treated effluent was recorded 327 mg/L. This is well within the limits of TNPCB Standard (600 mg/L). In the present investigation the BOD of the untreated effluent was 110 mg/L while the treated effluent recorded 10 mg/L. According to TNPCB standard the BOD should not exceed the 100 mg/L. In the present investigation the COD of the untreated effluents was 300 mg/L while treated effluent was recorded 168 mg/L. In untreated effluent it is appreciably high compared to TNPCB standard (250 mg/L). This indicated high organic pollutants in the sample. The germination percentage values shown in the table - 4.1 reveal the fact that percent germination of *Trigonella foenum* seeds is considerably high in treated effluent compared to untreated effluent.

SEED GERMINATION

(a) Control (b) Treated (c) Untreated

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It can be seen that all the values are within the TNPCB permissible limit. So effluents is discharged in to the nearly water system.

S.NO.	Parameters	Result as per TNPCB Standard (Untreated sample)	Result as per TNPCB Standard (Treated sample)	Tolerance limits for discharge of trade effluent (TNPCB standard)
1	Sulphate	1250 mg/L	761 mg/L	1000 mg/L
2	Chloride (Mohr's test)	524 mg/L	327 mg/L	600 mg/L
3	Total dissolved solids (TDS)	900 mg/L	500 mg/L	2100 mg/L
4	Total suspended solids (TSS)	950 mg/L	150 mg/L	200 mg/L
5	Biological oxygen demand in water (BOD)	110 mg/L	10 mg/L	100 mg/L
6	Chemical oxygen demand in water (COD)	300 mg/L	168 mg/L	250 mg/L
7	pH	6.80 Units	6.20 units	5.5-9.0 units

The treated food industries effluent can be used for irrigation purposes, because it helps in good germination of seeds compare to other effluents.

Bioremediation is an eco-friendly method by which wastewater can be treated to reduce various contaminants which would otherwise be carried into the environment. Different ameliorative techniques improved the quality of effluent by reducing the amount of pollutants present in it, and effectively reduced colour, pH, Suspended solids and oxygen demanding water present in the effluent. Dhanam [1] and Mohana et al [6]. Generally, in the presented study, chemical treatment improved the waste properties for seed germination and plant growth. These results are consistent with those obtained in where organic impurities removal from the contaminated wastewater of a plant was achieved by coagulation at pH- 2 to 12. Manu et al [10]. The treated effluent samples showed favourable effects on seed germination and other growth parameters of Maize at 20 mg/L, thus seed germination, seedling growth and dry matter production significantly differed with different treatments which might be due to presence of fewer toxic chemicals in the treated effluent, and the inhibitory effect of raw effluent might be due to the presence of a high level of toxic substances. Manu et al [5] and Mohana et al [6]. Also the results (Tab. 1 and 2) are considered with study found that the treatment of wastewater by coagulation-decantation with Iron chloride, Calcium Hydroxide, Aluminium Sulphate removed 40% organic matter and nitrogen content, and improved the treated water Fatta et al [2].
Relatively low pH values of both treated and untreated samples are due to use of phosphoric acid and Sulphur dioxide during cleaning of sugar cane juice. pH is one of the important biotic factors that serves as index for pollution. If such water is used for irrigation for a longer period the soil becomes acidic resulting in poor crops growth and yield. The factors like photosynthetic exposure to air, disposal of industrial effluent and domestic sewage also affect the pH of the soil. The total dissolved solids concentration in the effluent represent the colloidal form and dissolved spectres. The probable reason for the fluctuation or value of total solids and subsequent the value of dissolved solid due to convent collision of the colliding particles. The rate of collision aggregated process is also influenced by pH of this effluent. In the rainy season less concentration of total dissolved solids are obtain due to dilution of waste effluent with rain water Hosetti et al [4]. The total suspended solids affect the light intensity of water; suspended solids are the cause of

suspended particle inside the water body influencing turbidity and transparency. Sulphate can also be produced by factorial or an oxidizing action as in the oxidation action or in the oxidation of oregano sulphur compounds. Sulphur itself has never been limiting factor in aquatic system, the normal levels of sulphate are more than adequate to meet plants needs. Odors conditions are easily greater when water is over loaded with organic wastes which reduce the oxygen, SO_4 an electron acceptor is often used for the breakdown of organic matters and produces H_2S causing bad smell of rotten egg. Biochemical Oxygen Demand (BOD) is defined as amount of oxygen required by microorganism while stabilizing biological decomposable organic matter in water under aerobic conditions. The biological oxidation is very slow process during oxidation; organic pollutants are oxidized by certain microorganism into carbon dioxide and water using dissolved Oxygen. Hence lowering in dissolved oxygen value is the measure of BOD relation. The chemical Oxygen demand test determines the oxygen required for chemical oxidation of organic matter with the help of strong chemical oxidant. The COD is a test which is used to measure pollution of domestic and industrial waste. The effluent is measured in term of quality of oxygen required for oxidation of organic matter to produce carbon dioxide and water. It is a fact of all organic compounds with few exceptions that they can be oxidized by the action of strong oxidizing agents under acidic conditions. COD is useful in pinpointing toxic condition and presence of biological matters.
The germination, seedling growth and dry matter production of Lady's finger (Abelmoshusesculentus) significantly differed with different treatment using a physical treatment. The maximum promoting effect observed in the treated samples might be due to a reduction of pollutants in the filters. Dhanam, [1]. Germination percentage, seedling growth and dry matter production were inhibited in raw spent wash at higher concentrations of total salts making inhibition, The results in table and figure are in agreement with which indicated that the length of the root system and number lateral roots Vigna radiate increased with low concentrations of effluent. Similar results have been reported by which may be related with the elevated amounts of total dissolved solids at higher concentrations. This could also be related to the fact that some of the nutrients present in the effluents are essentials, but at high concentration they become hazardous. The study of, also showed that textile effluent were not inhibitory at low concentrations, but with the increase in concentrations, the growth of seedlings was affected. It was found that tannery effluents caused a reduction in germination and growth of sunflower parameters, together with other parameters, such as chlorophyll content, protein and carbohydrate content etc. Mohana et al [6].

In the present study, impact of wastewater emanated from 5 Star hotels and on seed germination and some physiological parameters of *T. foenum* were studied. Use of sewage for irrigation purposes has emerged an important way to utilize its nutrients and removal of its pollution load by growing tolerant plant species. The effect of sewage on seedling was significant at various concentrations. Further the difference in seedling vigour index also showed a similar trend of statically significant with treatment at different concentrations. Germination efficiency, seedling length, seedling vigour index, and total chlorophyll content was found to be increased with increase in concentration of sewage upto 50% dilution after which it decreases. Thus, the sewage, after proper dilution can be used as a potential source of water for seed germination and plant growth in agricultural species

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