

Various Approaches in Treatment of Distillery Effluents and the Impact of Distillery Effluents on Fishes: A Review

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ABSTRACT

Both nationally and internationally, the toxicity of the distillery effluents creates severe issues in various respects. For the production of one litre alcohol, more than 13-15 litre of fresh water is required and the resulting waste water contains huge volume of toxicants. The by-products eliminated from such distilleries will adversely affect the ecosystem. The limited concentration of minerals and nutrients in the effluent may support the plant growth to greater extent. However, the adverse effects of distillery effluents rank more than its positive effect in the ecosystem. These aspects of distillery effluents are documented well by different researchers. This review paper throws light on various aspects of water and soil pollution caused by the distillery effluents. It specifically deals with decolourization methods of Melanoidin pigment, impacts of distillery effluent on various fishes, different physico-chemical properties and biological approaches engaging micro-organisms used for the treatment of distillery effluents.

KEYWORDS: Distillery effluent, Melanoidin, Chemical Oxygen Demand, Biological Oxygen Demand, Physico-chemical approaches, Biological approaches.

INTRODUCTION

The distilleries discharge huge amount of effluent (distillery spent wash) causes extensive pollution mainly on both soil and water ecosystem. Without proper treatment, the unwanted dark-brown coloured effluent accumulated in the ecosystem and leads to critical environmental issues (Agarwal et al. 2010, Pinto et al. 2016). In addition, the effluent contains very high biological oxygen demand, chemical oxygen demand, total solids, sulphate, phenol, and other toxic metals (Chowdhary et al. 2018a). Moreover, the distillery effluent (DE) contains number of recalcitrant organic pollutants including Butanedioic acid, 2-Hydroxy isocaproic acid, Vanillyl propionic acid and various heavy metals, etc., which is reported as endocrine-disrupting chemicals (Kumar and Sharma 2019).

The amount of pyrogenic compounds discharged through the formation of Melanoidin by the Maillard reaction will gradually leads to environmental carcinogenicity (Martins and Backel 2004). According to Chandraju et al. (2011) mentioned that

various recalcitrant organic pollutants found in the distillery effluent have significant effect to arrest the entry of sunlight in to the water column and there by adversely affecting the aquatic system. Besides this, the direct discharge of these untreated effluents causes various deleterious effects on soil, air and health. In addition to the organic pollutants, the presence of a dark coloured pigment, Melanoidin and its suspended solids in the waste water causes the hindrance of photosynthesis and decreases the dissolved oxygen content in water body. Both the alkaline content and high temperature of the effluent adversely affects the plant growth, crop production and soil fertility. Moreover, the presence of lactic acid, glycerol, ethanol and acetic acid causes several health problems to various organisms (Chaudhary and Arora 2011), because of high strength and disposing difficulty of such effluent, the long term ill effects behind the chemicals are very dangerous to entire life.

Various studies regarding the effect of distillery effluent on soil profile and water column was conducted by various researchers. According to

Somawanshi and Yadav (1990). The effect of distillery effluent on organic carbon in soil was studied by Biswas et al. (2009), Kukreja et al. (2012) which indicate the benefit of its minerals and nutrients to the crop plants in appropriate concentration. Latha et al. (2012) studied the effect of effluent by-products on the soil properties and found that the fertility could influence by the effluent by-products and it has the capacity to make some alterations in the biological properties of the soil. Goli and Sahu (2014) elaborated the complex nature of the soil that would be changed by the discharge of such effluents, which improves the salinity and diminishes the soil fertility.

Juwarkar and Dutta (1990) conducted a pot culture experiment to evaluate the effect of different treatments (raw, treated and diluted) of distillery waste water on the populations of bacteria, fungi, actinomycetes etc., indicated that the raw distillery waste water was very toxic to the soil microflora and also have the capability to reduce the growth and development of the micro organisms. Chauhan and Rai (2010) studied on ferti-irrigation impacts and indicated that the values of all the parameters (pH, electrical conductivity, chloride, sulphate, nitrate, chemical oxygen demand, total solids, total dissolved solids, sodium, potassium, calcium, magnesium total coliforms etc.) were decreased with increasing the depth of water column. Matta et al. (2014) investigated the effect of industrial effluent on the ground water quality with special reference to DO, BOD and COD effect and they pointed out that serious environmental and health issues were occurred by the accumulation of both treated and untreated waste materials in the surrounding water medium with fluctuated physico-chemical parameters in great extent. The impact of distillery effluent on the environment and its remedies was studied by Chowdhary et al. (2018b) clearly mentioned the discharged effluent with very high COD and BOD inhibits the seed germination and vegetation, they explained various approaches for the treatment such as physical, chemical and biological methods for the treatment of distillery waste water.

MELANOIDS

Melanoidins are heterogeneous polymers and major contributors to the dark brown colour of molasses spent wash causes environment pollution. In different countries various researchers have studied and explained various aspects of this particular colouring agent. The formation of Melanoidins from the Maillard reaction was studied by Echavarria et al. (2012) explained various steps behind the Melanoidin formation and described the different structures of Melanoidin which causes specific health effect. Removal of colour from distillery effluent with the assistance of natural Manganese oxides has been studied by Arimi et al. (2015) and the works culminate into a conclusion that Manganese oxide has the capacity to eliminate the colouring agent with respect to pH after anaerobic digestion of molasses distillery waste water. Nure et al. (2017) studied about the elimination of colour from molasses spent wash by using activated carbon from bagasse fly ash with the aid of Freundlich model and revealed that the initial COD concentration is essential for the removal of COD whereas colour removal was influenced by the contact time. The degradation of Melanoidin in distillery effluent with *Bacillus cereus* was studied by Girde (2019) explained the microorganism were reported to be greater potential for bioremediation as compared to other bacterial isolates because it has the capacity to decolourize the distillery effluent within the optimum physico-chemical parameters (BOD and COD) and these micro organisms provide cost effective and ecofriendly approaches for the treatment of distillery effluent. . Study on the effect of pH on Melanoidin extraction from post methanated distillery effluent (PMDE) and its decolourization by potential bacterial consortium was conducted by Yadav and Chandra (2013) explained that PMDE is a major source of both soil and water pollution which affects the animals and human beings directly or indirectly and also the decolourization of Melanoidin has influenced by the different streams of bacterias (*Proteus mirabilis* (IITRM5; FJ581028), *Bacillus sp.* (IITRM7; FJ581030), *Raoultella planticola* (IITRM15; GU329705) and *Enterobacter sakazakii* (IITRM16, FJ581031). Patel and Jamaluddin (2018) explained the adverse effects of

Melanoidin on land and various methods of treatments for waste disposal globally. There are different studies were conducted in national level on various aspects of Melanoidin. Singh et al. (2019) has pointed out that these heterogenous polymers were the major factors which cause the oxygen depletion and increase BOD and they concluded that the conventional methods of water treatment were insufficient for the removal of Melanoidin.

Chavan et al. (2006) studied about the degradation of Melanoidins by microbes and it focussed on the use of cost-effective and ecofriendly aspects for the biodegradation of Melanoidin pigment through screening of bacterial cultures with the help of *Pseudomonas* species. Study of bioremediation and decolourization of distillery effluent by novel Microbial consortium was conducted by Pal and Vimala (2012) and they pointed out that both *Pseudomonas aeruginosa* and *Aspergillus niger* in the form of consortium are satisfactory for the reduction of colour, sulphates, sulphites, COD and BOD than individual organisms. Shukla et al. (2018) conducted a comparative study on natural decolourizing agents for degradation of Melanoidin present in biomethanated molasses spent wash and gives an idea about the efficiency of soil, bagasse, jaggery and fly ash to remove colour of Melanoidin in which the combination of soil and bagasse were more effective. The study on degradation and detoxification of distillery wastewater pollutants by *Bacillus megaterium* sp. for environmental safety conducted by Chowdhary and Bhargava (2018c) identified the effectiveness of bacterial strain (*Bacillus megaterium* sp.) to decolourize the distillery waste water up to 63.26% with the presence of glucose (0.5%) and peptone (0.1%) at particular pH (7.0) and temperature (35 °C) in axenic culture conditions.

PHYSICO-CHEMICAL PROPERTIES OF DISTILLERY WASTE WATER

Studies on physico-chemical properties of distillery effluent were conducted worldwide. Heredia et al. (2005) studied about the physico-chemical treatment for the depuration of wine distillery waste waters by the establishment of an integrated Fenton-coagulation/flocculation process with two stages

involved for the removal of chemical oxygen demand. The study of the effect of distillery effluent on certain agricultural crops was done by Ale et al. (2008) in Nepal and stipulated that all the physico-chemical parameters such as pH, temperature, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total suspended particles, nitrogen, phosphorus, potassium and some heavy metals like iron (Fe), manganese (Mn), cadmium (Cd), lead (Pb), zinc (Zn), and copper (Cu) were above the permissible level of toxicity set by Nepal Bureau Standard and also these parameters were adversely affected the soil quality and crop productivity. The analysis of physico-chemical characters of distillery effluent from Ethiopia was conducted by Bezuneh and Kebede (2015) and focussed on the parameters which indicated the level of pollution at their peak. The physico-chemical characters and its effects on water quality of Musamya River was done by Turinayo (2017) and pointed out a higher level of pollutant concentration than the permissible range would be the reason for the fluctuation of water quality. While, Ogemdi and Gold (2018) also studied about physico-chemical parameters of effluents from the Brewery industry in Nigeria and the results indicated that the effluents have high BOD, COD, EC, turbidity and colour than the WHO/FEPA standards that created many health issues to several rural communities. Similar studies were conducted at national level also. The Physico-chemical characteristics of distillery effluent and its dilution effect at different levels has studied by Ansari et al. (2012) and showed that both the spent wash and primary treated distillery effluent contains large volume of chemical pollutants and these pollutants could be reduced with increased dilution such as 50% and 70% of water. Vasanthy et al. (2004) conducted a study about the parameters of both treated as well as untreated effluent and found that the acidic and dark brown colour was due to the presence of large volume of pollutants in the medium and also the conductivity was reckoned higher. The physico-chemical parameters from both raw and diluted distillery effluent was identified and analysed by Pugazh et al. (2016) in Tamil Nadu and clearly indicated that the raw effluent contains high load of organic pollutants such as colour, odour, pH, electrical conductivity (EC), total solids (TS), total

dissolved solids (TDS), total suspended solids (TSS), total hardness, chemical oxygen demand (COD), dissolved oxygen (DO), calcium, chlorides, magnesium, potassium, and sulphates etc.

According to Pandey et al. (2007) analysed the physico-chemical parameters and its effect of distillery effluent on seed germination in wheat (*Triticum aestivum*), Pea (*Pisum sativum*) and lady's finger (*Abelmoschus esculentus*) and they pointed out that the increasing concentration of effluent was inversely proportional to the percentage of germination because the effluent contains large amount of both organic as well as inorganic pollutants. Physico-chemical analysis of treated distillery effluent irrigation responses on crop plants such as pea and wheat was done by Pandey et al. (2009) and indicated that the acidic nature of effluent with high dissolved salts and organic pollutants cause an inhibitory effect on the crop plants. A study on the physico-chemical parameters of Rapti River water in Uttar Pradesh was conducted by Chaurasia and Tiwari (2011) and focussed on the water quality by analysing various parameters like temperature, pH, EC, DO, BOD, COD, chloride, nitrate, phosphate, sulphate, free CO₂, alkalinity, total hardness, total solids and oil and grease showed the worst conditions of the river that carried effluent from the distillery unit. Ray et al. (2016) the various parameters of distillery effluent revealed that all the parameters such as colour, odour, total solids, total dissolved solids, total suspended solids, pH, electrical conductivity, total hardness, calcium, magnesium, alkalinity, chloride, dissolved oxygen, biological oxygen demand, chemical oxygen demand, ammonical nitrogen, total phosphorus, and total potassium were covered large volume of chemical pollutants and which was the major cause for the water toxicity. Another study regarding the physico-chemical characteristics and biological treatment of molasses based distillery effluent was done by Chaudhary et al. (2013) and proposed that the effective biological treatment for the effluent by-product contains very high bod and cod was clearly reduced (BOD, 76% and COD, 62%) with the assistance of various bacterial consortiums of *Pseudomonas grimonti*, *Bacillus* sp. *MH-I6* and *Staphylococcus* sp. *CSA* strain. A comparative study of BOD, DO and pH of distillery treated and

untreated waste water in major part of India was done by Tripathi et al. (2015) and reported that the untreated effluent contains large volume of 'BOD' and low contents of 'DO' than the treated effluent, so that these untreated effluents were more toxic and inappropriate for irrigation purposes without proper treatment.

IMPACT OF DISTILLERY EFFLUENT ON FISHES

Fishes are considered as the bioindicators and exhibit some special movements in the water column, when the physico-chemical property of water changes. Both fishes and aquatic organisms affected adversely with the administration of distillery effluents in the water body (Prakash and Singh 2020). Various studies have been carried out on the impact of distillery effluent on various physiological parameters in the fishes.

Study concerning the impact of distillery effluent on carbohydrate metabolism in *Cyprinus carpio* was done by Ramakritinan et al. (2005) and pointed out that the increasing effluent concentration is inversely proportional to the carbohydrate metabolism. A comparative study was conducted by Patil and Ghole (2010) on the toxicological studies of the distillery effluent on *Cyprinus carpio* using the effectiveness of the two step process (UASB) reactor followed by an oxidizer showed an acute toxicity of both anaerobically treated distillery effluent and oxidized effluent on carp fish through the analysis of various responses elicited by the fish such as behavioural and histopathological alterations. Shukla and Shukla (2013) conducted a study on the impact of Gorakhpur distillery effluent on the fingerlings of *Colisa fasciata* at various concentration levels (5, 10 and 20%) on the haematological parameters and revealed that between the concentration of 10 and 20% of distillery effluent elicited significant alterations in hematocrit as well as clotting time in the blood profile of *C. fasciata* than the 5% effluent concentration. According to Prakash and Singh (2020), *C. carpio* exhibited decreased rate of oxygen uptake under the exposure of distillery effluent because they were very sensitive to distillery effluent toxicity.

A study concerning how distillery waste water influences the glycogen and lipid content during

ovarian cycle on the tropical fresh water fish was done by Shukla and Shukla (2015) and reflected the toxic effects of distillery waste water through a declined level of glycogen and lipid profile during three reproductive phases (preparatory, spawning and post spawning) and alterations in the behavioural responses like the swimming activity, loss of equilibrium, mortality rate and histopathological changes. A study on the effect of distillery effluent on the nucleic acids and proteins profile in the fresh water fish *C. fasciata* was done by Shukla and Shukla (2012) and pointing out that the concentration of distillery effluent between 10 and 20% caused fluctuations in the nucleic acids, protein content at all the phases of ovarian cycle and the biochemical parameters were significantly declined in the spawning phase compared to other two phases.

The effect of both distillery and paper mill effluents on *Heteropneustes fossilis* and *Sarotherodon mossambicus* was done by Haniffa et al. (1986) and they points out that both the RBCs and WBCs were fluctuated with respect to increase in effluent concentration. Saxena and Chauhan (2003) studied about the oxygen consumption in *Labeo rohita*, and indicated a drastic increase in the rate of oxygen consumption due to significant reduction in the dissolved oxygen. Acute toxicity of distillery spent wash on Nile Tilapia (*Oreochromis niloticus*) fingerlings was done by Wongmaneeprateep et al. (2016) and reported about the adverse effect expressed by the fish on the behavioural changes such as opercular movement, recurrent air gulping at the water surface and mortality rate. The study regarding the acute industrial effluent toxicity to nine fresh water fishes such as major carps, cat fishes and murrels was done by Shaffi (1980) and clearly reported that industrial effluent concentration is directly related to levels of serum glucose and lactate and are more prominent in major carps than cat fishes. The impact of distillery effluent on *Mystus gulio* was investigated by Gulio et al. (2016) and they clearly reported that the fishes were showed alterations (behavioural, respiratory and histopathological) under stress due to the acute effluent toxicity of the water medium.

Saroja et al. (2013) studied about the effect of raw alcohol distillery effluent on the behavioural and biochemical aspects of *C. carpio* and pointed out that

there were some significant alterations such as erratic swimming, restlessness, respiratory distress, rapid jerky movements exhibited by fish due to some severe hypoxic conditions to meet the energy requirement. The study regarding the effect of distillery effluent on the reproductive organs of *Mystus vittatus* was investigated by Mishra and Singh (2009) and revealed that the fishes expressed noticeable seasonal alterations and susceptibility to sewage and distillery effluent especially in the spawning phases. A study of sustainability of *Catla catla* with distillery spent wash was done by Chandraju et al. (2011) and described that the *Catla* were more hypoxic in the contaminated water and such water creates deleterious impacts on the well-being of the particular fishes. Verma et al. (1979) studied about the effect of distillery waste on some fresh water teleosts (*Ophiocephalus punctatus* and *Saccobranchus fossilis*) through their biochemical aspects and mentioned the enzymatic activity such as alkaline and acid phosphatase in the liver and kidney of two teleosts decreased when significant increase in the exposure time.

Study considering the haematological alterations in fishes exposed to raw distillery waste was done by Saroja et al. (2019) and found severe alterations in different haematological parameters like RBC, WBC, Hb, PCV etc in *C. carpio*. While, Sousa et al. (2019) also investigated on hazardous impact of vinasse from distilled winemaking by-products in terrestrial plants and aquatic organisms and stipulated that vinasse promoted toxicological impacts on both terrestrial plants and aquatic animals in which the aquatic organisms were more affected directly by its acute effects.

TREATMENT FOR THE DISTILLERY EFFLUENT

The adverse effect of various effluents discharged from different industries contains large volumes of toxicants (organic, inorganic) affects both soil and aquatic systems directly or indirectly (Prasad et al. 2007). The adverse effect of such pollutants is reduced with the support of proper treatment and management strategies. Different techniques such as physico-chemical and biological have been employed to reduce the untreated effluent content

accumulated in the water column. At different aspects, a lot of work has been carried out by various researchers with well explained treatment methods. Various resources of distillery waste water treatments at global level have been studied and explained. The anaerobic digestion was one of the method to treat the distillery waste water has been investigated by Melamane et al. (2007) and focussed on the alteration when adding the micro as well as macronutrients in the bioreactor. The biotreatment of distillery effluent with UASB digester by anaerobic method was done by Goodwin et al. (2001) and concluded that the presence of volatile fatty acids (VFA) with significant amount of COD found in the period of reactor stress and the alkaline nature of waste water increased during digestion. The study of the combination of both anaerobic digestion and photo degradation process for the effluent treatment was conducted by Apollo and Aoyi (2016) and indicated that the colour removal was efficiently done with the application of both anaerobic digestion and photo degradation process than anaerobic digestion stand-alone. Manyuchi et al. (2018) conducted a study on the biological treatment of distillery effluent with the application of one species of earth worm, *Eisenia fetida* and they pointed out that the biological treatment method was highly effective for the reduction of downstream contamination of the effluent. Susree et al. (2013) investigated about the use of different means of electrochemical reactor with different operations such as batch electrochemical reactor, batch with recirculation and batch with single pass etc for COD removal and culminated that COD removal was increased in batch electrochemical reactor with respect to increased parameters like current density and electrolyte concentration than other two reactor operations.

More related works have been conducted in national level by researchers for various methods of treatment. Murthy et al. (2009) observed that the combination of ultra-filtration membrane and reverse osmosis were efficient methods to separate suspended solids, Total Dissolved Solids, Chemical Oxygen Demand, Biochemical Oxygen Demand, Sulphate and Potassium from distillery waste water. Ali et al. (2015) found that if there were different methods for the treatment of distillery effluents, such methods are insufficient for the proper management

of pollutants and hence they have made suggestions for the effective and efficient treatment of effluents. Kulkarni et al. (2016) presented one review paper titled with treatments of distillery spent wash by using various methods such as electro coagulation method, adsorption techniques, sand filtration techniques etc and clearly concluded that the method of effluent treatments with sand: dirt, sand: clay: ash, sand: clay: charcoal combination were more effective for the reduction of maximum percentage of colour and COD in distillery waste water. By using activated carbon as a natural adsorbent for the removal of spent wash pollutants has been studied by many researchers. Manisankar et al. (2003) on the distillery effluent treatment with anodes and analysed that the electrochemical technique was relevant for the removal of colour very well with the support of two different kinds of anodes through the maximum reduction of COD and BOD. Similarly, Manisankar et al. (2004) was also carried out a study on the treatment of distillery effluent by using halides and has explained both graphite anodes and cathodes provide effective methods for the treatment of such effluent. Pant and Adholeya (2007) presented a general review paper on the description of colour causing components, existing biological approaches and the function behind the microbial enzymatic activity for the proper treatment of distillery effluent. On the other hand, a study on the bioremediation approaches of distillery waste water was conducted by Kharayat (2012) and presented a review on some major issues associated with the distillery waste water and existing biological treatment methods while, Ayub and Usmani (2014) also explained the significant reduction of effluents with the aid of activated carbon in relation to three relevant parameters like adsorbent dosage, contact time and effluent dilutions.

CONCLUSIONS

It can be concluded that the distillery effluents includes huge volume of pollutants with recalcitrant organic matters. The dark brown colour of such toxicants has higher Chemical and Biological Oxygen Demand. The suspended particles in the spent wash hindered the sunlight and there by the trophic level of the aquatic ecosystem are adversely

affected. Various studies were reported its negative impacts on both soil as well as water bodies. The pigment of the distillery effluent, Melanoidin provides colour to the effluent, and various studies covered the decolourization methods for the removal of pigment, especially with the application of micro organisms. The removal of Melanoidin with the application of bagasse, jaggery and fly ashes are explained and biodegradation of such pigment by the support of microbial culture is discussed well in this content matter. Both physical and chemical parameters are reported as higher than the permissible rate. From the studies it is understood that the acidic nature of the effluent are the main reason for the alternation of water quality and also it affect the soil system directly.

Further, the results from various studies indicated that the fishes face serious threat due to the accumulation of such hot, acidic water in their ecosystem and remarkable declination of dissolved oxygen in the water column. It exhibited various impacts on the physiology of the fishes especially in the reproductive cycle. So distillery effluents are needs to be treated before they are discharged into a water or soil in order to minimize its effect on both fauna and flora. There are different approaches like physical, chemical and biological methods to be used for the treatment of distillery effluent. Both physical as well as chemical method provides the elimination of low level of organic pollutants because of its high selectivity. But these methods have disadvantages such as high operating cost, excessive use of chemicals etc. The toxic and adverse effects of distillery effluents could also reduced by the application of biological treatment.

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