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Sand Filtration as an Alternative Technique for the Treatment of Distillery Effluent

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Abstract
Distilleries produce large volume of wastewater which poses a considerable environmental impact by polluting water and soil bodies. The present study was conducted to find a simple and economical way for wastewater treatment. Wastewater released from distilleries was filtered by using different ratio of sand and clay soil with some amount of wood ash and charcoal. The result revealed that there was a significant reduction in parameters as: pH, COD, BOD, TDS, EC and heavy metal concentrations. Maximum percentage reduction in all parameter was obtained for the filtration with 3:1 sand and clay soil with some amount of crushed wood charcoal. Minimum reduction in all parameter was recorded for the filtration with 3:1 sand and clay soil.
Keywords: Wastewater, Physicochemical, Filtration-Bed

1. Introduction

Distilleries generate large volume of wastewater which is responsible for the pollution of natural environment. Wastewater from distillery is characterized by dark brown color, high organic and inorganic compounds, acidic pH and high chemical and biochemical oxygen demand (Terefe and Eyob, 2015, Susheel *et al*., 2007). The unpleasant odor of the effluent is due to the presence of malodorous compounds including hydrogen sulphide, organic acids and volatile fatty acids (VFA) including glycerol, butyric, lactic, acetic, tartaric, propionic and valeric acids (Mahimaraja and Bolan, 2004, Desauziers *et al*., 2000).

Wastewater released from distilleries is hazardous if it is disposed to the environment prior to any dilution or treatment procedure. It introduces foreign and toxic substances to the soil and water bodies which will result in change in physicochemical characteristics of the soil and water. It may result in eutrophication, reduction of sun light penetration in rivers, lakes or lagoons (Kumar 1995 and 1997). The change in the physicochemical property of soil and water bodies as a result of the addition of toxic substances poses an adverse effect on the animals, plants and aquatic life (Musee *et al*. 2007).

There are several technologies that have been explored for the treatment of wastewater. The method can be generally classified as physical, chemical and biological methods. Some of the physicochemical methods includes: adsorption (Sohail and Shoebuddin, 2014; Bama *et al*., 2013), oxidation (Fernando *et al*., 2002; Ebenezer *et al*., 2013), digestion (Prakash *et al*., 2014; Lekshmi, 2013), membrane treatment (Muhammad *et al*., 2011; Manyuchi and Ketiwa, 2013) and coagulation (Erick *et al*., 2011) methods.

Biological treatments can be grouped into aerobic or anaerobic methods where mostly microorganisms are involved in treatment process. The use of microorganisms as enzymes, algae, bacteria and funguses for bioremediation and decolorization of wastewater is the most economical and environmentally friendly method. Mostly bacteria and funguses are used to remove color from wastewater and some of them can be listed as: *coriolus sp*. (Yoshio, 1982; Suntud and Kanidtha, 1998), *trametes versicolor* (Pant and Adholeya, 2007), *aspergillus niger* (Sushil *et al.* 2014), *aspergillus fumigates* (Ohmomo *et al*., 1987), *lactobacillus* (Kumar *et al*., 1997; Siti *et al*., 2013), *Bacillus subtilis*, *pseudomonas aeruginosa* (Shubhangini and Pallavi, 2014), *Bacillus cereus* (Mao *et al*., 2011), *Aspergillus fumigatus* (Sadahiro, 1987; Mohammad *et al*., 2008), *Aspergillus nidulans* (Prajakta and Usha, 2012) and *Chaetomium globosum* (Prajakta *et al*., 2012).

There are different reports showing the importance of enzymes and algae in wastewater treatment. Algae are considered ideal for the treatment of wastewater discharged from different industrial sectors as distilleries. Algae contribute in reduction of surface and ground water pollution in different ways such as: by reducing eutrophication, remove nutrients (phosphates, nitrates, sulphates and metals), heavy metals and also enhances the amount of dissolved oxygen in water by reducing BOD and COD (Fallowfield and Garrett 1985, Picot *et al*. 1991). There are also various enzymes used for the treatment of wastewater where most of the enzymatic treatment is physical, chemical and biological treatments. A large number of enzymes were used so far where peroxidases, oxidoreductases, cellulolytic enzymes cyanidase, proteases, amylases are some of them (Klibanov *et al*., 1980; Klibanov *et al*., 1981; Aitken *et al*., 1989; Duff *et al*., 1994; Ferrer *et al*., 1991).

Wastewater treatment needs heavy investment and due to this reason effluents are released to the environment with partial treatment or without any treatment especially in developing country. The disposal of the effluents can affect the natural environment which in adverse causes significant effect on aquatic biota as well as human being. Therefore the aim of the present study is to devise a simple and economical method of wastewater treatment disposed form distilleries.

2. Materials and Methods

2.1 Sample Collection

The effluent samples were collected from one of the National Alcohol and Liquor Factory (NALF) found in Addis Ababa, Ethiopia. Materials used for water sampling were washed thoroughly with detergent solution, 10 % HNO_3, and finally with distilled water prior to sample collection. Samples were collected properly by using plastic bottles prepared for sampling. The collected samples were coded, stored and transported to the laboratory where further investigation performed. The pH and temperature of the water was recorded in-situ before the sample taken to the laboratory. Every procedure performed during sample collection and sample handling was according to standard set by American public health association (APHA, 1998).

2.2 Experimental Design of Filtration media

The material used for the treatment of the effluent was constructed from three different cylindrical tanks (Tank1, Tank 2 and Tank 3) with 32 cm in diameter and 67 cm in height (each of them has a total volume of 53,885 cm^3) Figure 1. The ratio of sand to soil which was 3:1 used for filtration purpose was adopted from Prasad *et al*. (2007). The three tanks were filled with 3:1 ratio of sand and clay soil where in addition 500 g of crushed wood ash and 500 g crushed charcoal were added in Tank 2 and Tank 3 respectively.

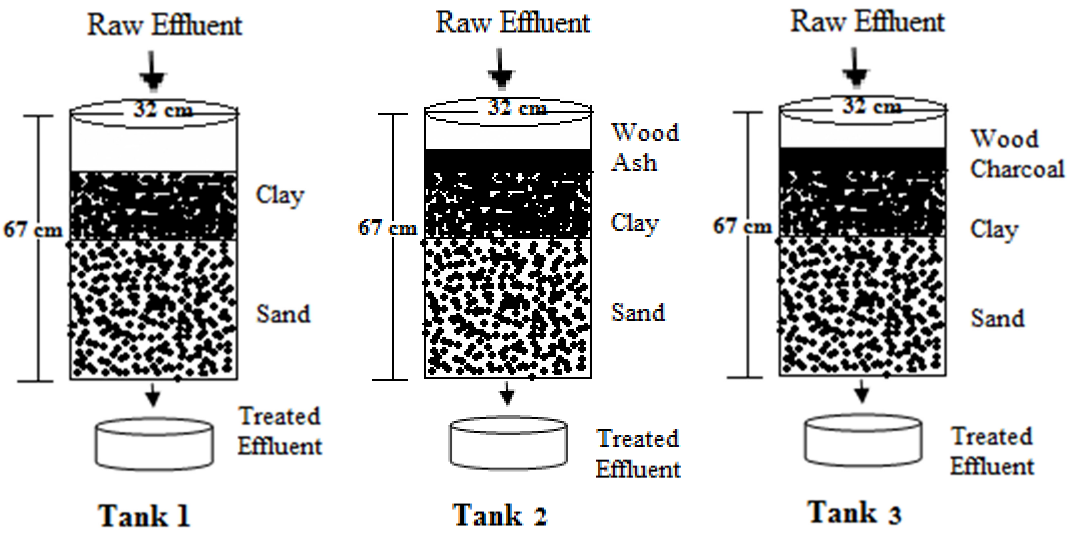

Figure 1. Schematic diagram of laboratory scale filtration materials

2.3 Analysis of Raw and treated Effluent

The most commonly determined physicochemical parameters as: pH, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductivity (EC), biological oxygen demand (BOD), chemical oxygen demand (COD) and concentration of Na, K and heavy metals were measured as per standard method (APHA, 1989).

3. Results and Discussion

The physicochemical characteristics of distillery effluents before and after treatment were analyzed and the values of different parameters i.e. pH, TDS, BOD, COD, EC, DO and concentration of potassium, sodium and heavy metals were presented in Table 1.

Table 1. Physicochemical characteristics of raw and treated effluents

Parameters	Unit	Raw Effluent	Results After Treatment		
			Tank 1	Tank 2	Tank 3
pH	-	3.4±0.03	5.75 ± 0.11	8.3±0.02	8.1±0.02
TDS	mg/L	34900±121	2758 ± 22 (-92.10)	3546±28 (-89.80)	2544±15 (-92.70)
EC	µS/cm	80000 ±	15500± (-80.60)	17000± (-78.75)	14160± (-82.30)
DO	mg/L	0.1 ± 011	0.12±0.1 (+20)	0.13±0.1 (+30)	0.15±0.1 (+50)
BOD	mg/L	14704 ± 259	4211±102 (-71.40)	3529±139 (-76)	3176 ±87 (-78.40)
COD	mg/L	33710.8 ± 398	9310 ±45 (-72.38)	8737±72 (-74.08)	8593±82 (-74.51)
Na	mg/L	188.8 ± 0.011	186.4±12.1 (-1.27)	91.8±1.6 (-51.38)	84±0.11 (-55.5)
K	mg/L	985 ± 45	134 ±18 (-86.40)	150 ±24 (-84.77)	173 ±11 (-82.44)

Values are represented as mean (n=3) ± SD. Values given in parenthesis indicates % increase/decrease

The acidic pH of the raw effluent (3.4) was increased to pH of 5.75, 8.3 and 8.1. Parsad *et al*. (2007)

also reported an enhanced pH of distillery effluent treated by mixtures of sand and soil. The pH obtained after treatment in sand: clay: ash and sand: clay: charcoal combination was within the recommended level of the standard set for irrigation purpose (6.5-8.4) (Pescod, 1992; FAO, 1985).

The Electrical conductivity was reduced from 80000 µS/cm to 15500 µS/cm, 17000 µS/cm and 14160 µS/cm which were about 80.6 %, 78.75 % and 82.30 % respectively. The maximum permissible electrical conductivity for irrigation set by standards was 3000 µS/cm. The electrical conductivity of the treated effluent was within the permissible level of the standard (Pescod, 1992; FAO, 1985).

Total dissolved solid (TDS) of raw effluent were recorded as 34900 mg/L which was reduced to 2758 mg/L 92.10 %, 3546 mg/L 89.80 % and 2544 mg/L 92.70 % in the treated effluent. The result obtained was closer to the standard prescribed for irrigation (Pescod, 1992 and FAO, 1985). Prasad *et al.* 2007 also reported 95.29 % reduction in TDS in sand and clay filtration of the effluent. The reduction in TDS was suspected due to retention of these solid particles in the filtration bed (Prasad *et al*. 2007).

The value of COD in raw effluent was found to be 33710.8 mg/L and was reduced to 9310 mg/L, 8737 mg/L and 8593 mg/L. Maximum removal was recorded for sand: clay: charcoal filtration which was about 74.51 %. There are different reports revealing the efficiency of mixtures of sand and soil in different ratios in removing COD from wastewater (Rao *et al*., 2003).

BOD of raw sewage was recorded as 14704 mg/L and was reduced to 4211 mg/L, 3529 mg/L and 3176 mg/L in sand: clay, sand: clay: ash and sand: clay: charcoal filtration respectively. This can be 71.4 %, 76 % and 78.40 % reduction in BOD respectively. Maximum reduction was recorded for sand: clay: charcoal filtration and minimum reduction for sand: clay mixture. Even though the result have been reduced highly it is above the maximum level set by standards for the irrigation purpose (Pescod, 1992; FAO, 1985). There are findings supporting the present result which is reduction of BOD by sand and clay filtration. More than 60 % reduction in BOD was reported by Elis *et al*. 1987 and Prasad *et al*. 2007.

The amount of dissolved oxygen (DO) is an important parameter in assessing the quality of water and it is also a determinant factor in sustaining the aquatic life. The concentration of DO in raw effluent was recorded as 0.1 mg/L. There were slight improvement in the amount of DO after treatment and the result was recorded as 0.12 mg/L in sand and clay filtration, 0.13 mg/L in sand and clay with small amount of wood ash and 0.15 mg/L in sand and clay with slight amount of charcoal added.

The concentration of K and Na in the raw effluent was 985 mg/L and 188.8 mg/L respectively. Maximum removal of Na was obtained for sand: clay: charcoal filtration and minimum removal was recorded for sand: clay combination. Higher concentration of sodium in irrigation affects the growth of the plant by affecting soil characteristic such as by reducing its permeability (Nemade and Shrivastava, 1996(b)). The concentration of Na obtained after treatment with sand: clay: charcoal mixture was within the prescribed standard set for irrigation (Pescod, 1992 and FAO, 1985). vvvvv

Table 2. The concentration of Heavy Metals in raw and treated effluent

Parameters	Raw Effluent (mg/L)	Results After Treatment		
		Tank 1	Tank 2	Tank 3
Fe	247 ± 0.006	134 ± 0.006 (46)	106±0.001 (57)	101.2±0.002 (59)
Mn	7.5 ± 0.005	3.77±0.003 (50)	2.12±0.005 (72)	1.50±0.007 (80)
Cr	2.76 ± 0.001	1.075±0.008 (81)	0.425±0.015 (85)	0.33±0.002 (88)
Cd	0.57 ± 0.008	0.4±0.011 (30)	0.440±0.015 (23)	0.21±0.003 (63)
Zn	1.63 ± 0.009	1.05±0.002 (36)	0.44±0.004 (73)	0.34±0.003 (79)
Cu	0.58 ± 0.001	0.50±0.006 (14)	0.30±0.007 (48)	0.14±0.004 (76)
Co	1.51 ± 0.003	1.13±0.023 (25)	0.89±0.009 (41)	0.53±0.009 (65)
Ag	0.56± 0.007	0.41±0.015 (27)	0.51±0.012 (9)	0.26±0.002 (54)
Ni	2.07 ± 0.013	1.70±0.004 (18)	1.67±0.008 (19)	1.02±0.003 (51)

Values are represented as mean (n=3) ± SD. Values given in parenthesis indicates % increase/decrease

Some of the heavy metals such as copper, manganese, zinc, iron, nickel and chromium are essential for biochemical and physiological function of plants and animals at trace amount (Nagajyoti *et al*. 2010). The concentrations of heavy metals in the untreated effluent were above the standard set for irrigation purpose except zinc which is in the permissible level (Pescod, 1992; FAO, 1985). Maximum percentage reduction of heavy metals was recorded in sand-clay soil filtration bed with wood charcoal. The concentration of Fe in the raw effluent (247 mg/L) was reduced by 59.02 % to 101.2 mg/L in the filtered effluent from Tank-3. The concentration of manganese in raw effluent (7.5 mg/L) was reduced by 80% to 1.5 mg/L in the filtered effluent. Similarly, concentration of Cu, Cd, Cr, Zn, Ag, Co, and Ni in raw effluent was 0.58 mg/L, 0.57 mg/L, 2.76 mg/L, 1.63 mg/L, 0.56 mg/L, 1.51 mg/L, and 2.07 mg/L, respectively were reduced by 76%, 63%, 88%, 79%, 54%, 65%, and 51%, respectively in the filtered effluent.

In general the maximum percentage reduction in each parameter has been found in the filtration bed containing sand, clay and wood charcoal. Minimum percentage reduction in each parameter has been found in the filtration bed containing sand and clay. The efficiency of the filtration bed can be ordered as sand: clay < sand: clay: ash < sand: clay: charcoal combination. The use of crushed wood charcoal having micro pores matrix with relatively greater active surface increases the adsorptive capacity in the filtration with sand: clay: charcoal filtration.

4.0. Conclusion

Distilleries releases huge amount of wastewater which imparts foreign and toxic substances to the water and soil bodies. Wastewater released to the environment prior to any treatment procedure poses a threat to the natural environment. There are so many advanced technologies developed for wastewater treatment but most of them are not economically viable especially in developing countries. But it is possible to reduce pollution from wastewater by using locally available materials. The application of sand and soil can also be considered as an alternative and economical method to treat wastewater.

5.0. References

[1] APHA (American Public Health Association) (1998). Standard methods for the examination of water and waste water, 20th edition (APHA) Publisher, Washington DC.
[2] APHA (American Public Health Association) (1989). Standard methods for the examination of water and wastewater. Seventeenth edition (APHA) Publisher. Washington, DC.
[3] Aitken M D and Irvine R L (1989). Stability Testing of Ligninase and Mn peroxidase from Phanerochaete Chrysosporium. Biotechnology and Bioengineering, 34(10), 1251-1260.
[4] Bama P, Thushyanthy M, Alvappillai P *et al*. (2013). Evaluation of lab scale constructed wetlands to treat the toddy distillery effluent with different aquatic plants. Archives of Applied Science Research, 5(5), 213-219.
[5] Desauziers V, Avezac M and Fanlo J L (2000). Simple analysis of odours fatty acids in distillery effluent by capillary electrophoresis. Analusis, 28, 163-167.
[6] Duff S J, Moritz J W and Andersen K L (1994). Simultaneous Hydrolysis and Fermentation of Pulp Mill Primary Clarifier Sludge. Canadian Journal of Chemical Engineering, 72(6), 1013-1020.
[7] Ebenezer A V, Arulazhagan P, J.Rajesh Banu *et al*. (2013). Coupled ozonation with aerobic sequential batch reactor for treatment of distillery wastewater. International Journal of Current Microbiology and Applied Science, 2(6), 137-145.
[8] Erick B, Yung-Tse H, Ruth Y Y *et al*. (2011). Electrocoagulation in Wastewater Treatment. Water, 3, 495-525.
[9] Ellis K V (1987). Slow sand filtration as a technique for the tertiary treatment of municipal sewages. Water Research, 21, 403-410.
[10] Ferrer I, Dezotti M and Duran N (1991). Decolorization of Kraft Effluent by Free and Immobilized Lignin Peroxidases and Horse Radish Peroxidases. Biotechnology Letters, 13(8), 577-582.
[11] Fallowfield H J & Garrett M K (1985). Treatment of wastes by algal culture. Journal of Applied Microbiology, 59(s14), 187S-205S.
[12] Fernando J B, Pedro M A, Eva M R (2001). Treatment of High Strength Distillery Wastewater (Cherry Stillage) by Integrated Aerobic Biological Oxidation and Ozonation. Biotechnology Progress, 17, 462-467.
[13] FAO (1985). Guidelines: land evaluation for irrigated agriculture. Soils Bulletin 55.Food and Agriculture Organization of the United Nations, Rome, Italy.
[14] Kumar V, Wati L, FitzGibbon F *et al*. (1997). Bioremedation and decolorization of anaerobically digested distillery spent wash. Biotechnology Letters, 19(4), 311-313.
[15] Klibanov A M, Alberti B N, Morris E D *et al*. (1980). Enzymatic Removal of Toxic Phenols and Anilines from Wastewaters. Journal of Applied Biochemistry, 2(5), 414.
[16] Klibanov A M & Morris E D (1981). Horseradish Peroxidases for the Removal of Carcinogenic Aromatic Amines from Water. Enzyme and Microbial Technology, 3(2), 119-122.
[17] Kumar S, Sahay S S and Sinha M K (1995). Bioassay of distillery effluent on common Guppy, Lebistes reticulates (peter). Bulletin of Environmental Contamination and Toxicology, 54, 309-316.
[18] Lekshmi S R (2013). Treatment and Reuse of Distillery Wastewater. International Journal of Environmental Engineering and Management, 4(4), 339-344.
[19] Mahimaraja S and Bolan N S (2004). Problems and Prospects of Agricultural Use of Distillery Spent Wash in India. Super Soil. 3rd Australian New Zealand Soil Conference, 5-9.
[20] Manyuchi M M and Ketiwa E (2013). Distillery Effluent Treatment Using Membrane Bioreactor Technology Utilising Pseudomonas Fluorescens. International Journal of Scientific Engineering and Technology, 2(12), 1252-1254.
[21] Mao Y L, Tian C X, Zhu J W *et al*. (2011). "Production of a Novel Biopolymer by Culture of *Bacillus*

cereus B-11 Using Molasses Wastewater and its Use for Dye Removal". Advanced Materials Research, 230(232), 1119-1122.

[22] Musee N, Treise M A and Lorenzen L (2007). Post-Treatment of Distillery Wastewater after UASB using Aerobic Techniques. South African Journal of Enology and Viticulture, 28(1), 51-55.

[23] Muhammad R B, Priscilla D, Anna P *et al*. (2011). Treatment of molasses wastewater in a membrane bioreactor: Influence of membrane pore size. Separation and Purification Technology, 78, 105-112.

[24] Mohammad P, Ghasem N and Mohammad R H (2008). Kinetic models of cell growth, substrate utilization and bio-decolorization of distillery wastewater by Aspergillus fumigatus U_{B2}60. African Journal of Biotechnology, 7(9), 1369-1376.

[25] Nagajyoti P C, Lee K D and Sreekanth T V M (2010). Heavy metals, occurrence and toxicity for plants: a review. Environmental Chemistry Letters, 8(3), 199-216.

[26] Nemade and Shrivastava V S (1996(b)). Metals in distillery effluents and their impact on surrounding ground water and plant tissues. Indian Journal of Environmental Health, 35(4), 228-293.

[27] Ohmomo S, Yasuyuki K, Suntud S (1987). Decolorization of molasses waste water by a thermophilic strain, aspergillus fumigatus G-2-6. Agricultural and Biological Chemistry, 51(12), 3339-3346.

[28] Pant D and Adholeya A (2007). Enhanced production of ligninolytic enzymes and decolorization of molasses distillery wastewater by fungi under solid state fermentation. Biodegradation, 18, 647-659.

[29] Prasad G, Rajput R and Chopra A K (2007). Alternative Economic Technology for Treatment of Distillery Effluent to Prevent Surface and Ground Water Pollution. Journal of Applied Science and Environmental Management, 11(3), 35-39.

[30] Picot B, El Halouani H, Casellas C *et al*. (1991). Nutrient removal by high rate pond system in a Mediterranean climate (France). Water Sci. Technol., 23(7-9), 1535-1541.

[31] Prajakta A M, Pradnya M W and Usha P (2012). Biodegradation of Distillery Effluent by Fungi. Bioscience Discovery, 3(2), 251 -258.

[32] Pescod M B (1992). Wastewater treatment and use in agriculture. Bull FAO 47: 125, Rome.

[33] Prakash N B, Vimala S and Raju V S (2014). Anaerobic Digestion of Distillery Spent Wash. ARPN Journal of Science and Technology, 4(3), 134-140.

[34] Rao R R, Reddy R C, Rao K G *et al*. (2003). Assessment of slow sand filtration system for rural water supply schemes – A case study. Indian Journal of Environ Health, 45(1), 59- 64.

[35] Shubhangini S and Pallavi M (2014). Decolorization of melanoidin pigment through Bacillus subtilis Pseudomonas aeruginosa, their consortium and optimizing the effect of carbon source. International Journal of Education and Science Research Review, 1(2), 17-25.

[36] Sohail A and Shoebuddin U (2014). Treatment of Distilleries and Breweries Spent Wash Wastewater. International Journal of Research in Engineering and Technology, 03(02), 204-214.

[37] Suntud S and Kanidtha C (1998). Some properties of coriolus sp. No.20 for removal of color substances from molasses wastewater. Thammasat International Journal of Science and Technology, 3(2), 74-79.

[38] Susheel K S, Amit S and Saiqa I (2007). Analysis and Recommendation of Agriculture Use of Distillery Spent wash in Rampur District, India. E-Journal of Chemistry, 4, 390-396.

[39] Sushil K, Ashutosh T and Mishra P K (2014). Fungal Decolorization of Anaerobically Biodigested Distillery Effluent (ABDE) Following Coagulant Pretreatment. International Journal of Science, Environment and Technology, 3, 723- 734.

[40] Sadahiro O, Yasuyuki K, Suntud S A *et al*. (1987). Decolorization of Molasses waste water by a Thermophilic Strain, Aspergillus fumigatus G-2-6. Agricultural and Biological Chemistry, 51(12), 3339-3346.

[41] Siti Z M, Nurhaslina C R and Ku Halim K H (2013). Removal of Synthetic Dyes from Wastewater by Using Bacteria, Lactobacillus delbruckii. International Refereed Journal of Engineering and Science, 2(5), 2319-1821.

[42] Terefe T B and Eyob M K (2015). Physicochemical Characterization of Distillery Effluent From One of the Distilleries Found in Addis Ababa, Ethiopia. Journal of Environmental and Earth Science, 5(11), 41-46.

[43] Yoshi W, Ryozo S, Yonemi T *et al*. (1982). Enzymatic Decolorization of Melanoidin by Coriolus sp. No. 20. Agricultural and Biological Chemistry, 46(6), 1623-1630.