ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

IJESRT

A Review On Research On Application Of Trickling Filters In Removal Of Various Pollutants From Effluent

Sonali R. Dhokpande[1], Sunil J. Kulkarni[2*], Dr. Jayant P. Kaware[3]
[1,2]Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India
[3]Bhonsla College of Engineering & Research, Akola, Maharashtra, India
[1]srdhokpande@gmail.com
[2*]suniljayantkulkarni@gmail.com
[3]jayantkaware@gmail.com

Abstract

Waste water treatment by using biological methods is very important area of research in environmental field because of its advantages and applicability. The suspended growth processes like activated sludge process are common in treatment facilities. Various aspects of biological processes for removal of various pollutants are being studied by investigators. The current review aims at studying the trickling filter systems for removal of various pollutants. The review of research carried out to study various aspects of trickling filter system with respect to its efficiency, operating parameters, economy of the process are presented in this paper. It was observed that the trickling system has been used very effectively in laboratory scale. In many investigations, pilot plant and further scale up was also done successfully. Trickling filter system with or without some modifications have been used successfully for removal of organic and inorganic matter, pathogens.

Keywords: percent removal, loading, effluent.

Introduction

In the current scenario of industrial civilization, use of efficient and economical treatment facility for waste water is very important area of research. The organic and inorganic pollutants like phenol, dyes, heavy metals are cause of concern for man and environment. Biological treatments of wastewater are very common and sought after methods.The suspended growth methods like activated sludge process(ASP) are often used in treatment plants. The attached growth processes are becoming increasingly important because of the disadvantages of ASP like inability to handle shock loads, power requirement and production of large amount of sludge.The attached growth processes such as trickling filter(TF) are gaing importance because of their own advantages.Trickling filter is suitable in areas where large tracts of land are not available for a treatment system. Also it is Effective in treating high concentrations of organic material depending on the type of media used.Also it can handle shock loads and produces less sludge. In the current review , the research carried out for application of trickling filters for wastewater treatment is summarized with respect to the aim, objective, methods and findings.

Trickling Filters For Removal Of Various Pollutants From Wastewater

A review on the design criteria of biological aerated filter (BAF) for chemical oxygen demand (COD), ammonia and manganese removal in drinking water treatment was done by Hassimi et.al.[1]. Their review was focused on the height and diameter dimensions for the BAF process system as well as the removal efficiency and the type of media used. The effect of biofilm growth, reactor configuration, aeration and backwash system on the BAF process was also studied in order to select the best design configuration for the BAF systems. The expected removal efficiency of COD and ammonia was within 80-90%.The review showed that a BAF dimension with H/D ratio of 8 to 22 has a good removal for COD of 80-90%. The studies on models for trickling

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

filter process design were carried out by Logan et.al[2].Their model was based on biofilm model, first order uptake kinetics and laminar flow in thin films.It was assumed that that flow pattern over a biofilm is hydraulically identical to a Newtonian liquid flow down an inclined surface. The proposed trickling filter model was tested for accuracy by model prediction with several sets of laboratory, pilot plant and full scale data. It was observed that the removal kinetics was different for same wastewater but different media. With temperature, the fluid viscosity decreases, resulting in decrease in fluid residence time. Predicted soluble biological oxygen demand (sBOD) profiles for trickling filters at high organic loading also indicated good agreement with the observed removals. For all sets of readings the decrease in removal was observed with increasing loading.The trickling filter model succesfully predicted the sBOD removal in plastic media trickling filters. It was observed the rate of removal of pollutant was controlled by the diffusion to the biofilm and not uptake kinetics within biofilm. An investigation on efficiency of total nitrogen removal in activated sludge and trickling filter processes was carried out in Tehran North wastewater treatment plant by Nourmohammadi et. al.[3]. The treatment system included anoxic selector tank, aeration tank, final sedimentation, and trickling filter. To provide complete nitrification in trickling filter,supernant of dewatered sludge was fed, where nitrification was done and this was converted to nitrogen in anoxic tank. The study indicated that low concentration of organic carbon and high concentration of NH_4-N led to nitrification in TF. The nitrate denitrification to nitrogen gas occurred in selector area. Total nitrogen decreased approximately to 50% in biological process. This efficiency has been observed in returned flow around 24%from final sedimentation into TF.This TF process was found efficient than typical biological nutrient process.

.In the changing scenario of environment, it is very important to develop an efficient compact, low cost treatment system that complies with applicable laws. Chemically enhanced trickling filter was studied for fast track evaluation of annual treatment cost by Ahemad[4]. The effect of different chemicals was incorporated through empirical performance formulas. The analysis of the results of the performance of the first stage of the treatment scheme indicated that about 80 % of the biological pollution load can be removed by the upstream chemical treatment at an optimal dose. The optimal economic dose of iron salts was 30 to 40 ppm according to unit capacity and characteristics of the influent. A review on improvements in biofilm processes for wastewater treatment was carried out by Ibrahim et. al[5]. The purpose of the review was to provide an overall vision of biofilm technology as an alternative method for treating waste waters.It was noticed during the review that fixed-film biological systems have been used widely in the treatment of wastewater, particularly in the attainment of secondary effluent standards and nitrification. Biofilm processes are attractive treatment processes and continue to be major research area, still being investigated.The modified trickling filter with a chitosan membrane coated matrix bed at the bottom, followed up by a conventional matrix bed was proposed by Soontarapa and Srinapawong[6]. They treated raw domestic wastewater from Sipraya water quality improvement factory in Bangkok. The waste water was taken in the equalization tank. It was shown that chitosan could be extracted from the dried shrimp shells in the same range as others. The consistency of the chitosan membrane coated on the matrix was evaluated by observing the uniform appearance during coating and the resulting membrane weight. It was observed that a uniform coating was obtained and the average membrane weight coated on the matrix was 0.0135 g. Also It was seen that by replacing with precultivated matrix, the assimilation time was shortened. They concluded that a chitosan membrane on trickling filter matrix, usually made of an inorganic material, could improve the wettability and enhance the adherence of microorganisms useful for wastewater treatment. Simsek and Ohm collected dissolved organic carbon (DOC) and Biodegradable DOC (BDOC) data along the treatment trains of two wastewater treatment plants (WWTPs) with a two-stage trickling filter (TF) system and an activated sludge (AS) + moving bed bioreactor (MBBR) system[7]. A comprehensive data collection study was conducted to examine the fate of DOC and BDOC for the treatment trains of two

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

different WWTPs equipped with (1) a two-stage trickling filter system (Fargo WWTP), and (2) an activated sludge + MBBR system (Moorhead WWTP). The BDOC fraction of DOC was about 70% in the primary clarifier and it was gradually decreased through the final effluent.This study showed that at least 27% of the effluent DOC in the Fargo plant and about 37% of the effluent DOC in the Moorhead plant can be biodegradable with the method used in this study and about 7 mg/L and 17 mg/L of effluent DOCs were stayed as biorecalcitrant in the Fargo and Moorhead WWTPs, respectively. It was observed that DOC and BDOC removal efficiencies in the BOD and nitrification trickling filters were higher in the Fargo plant compared to those in the activated sludge and MBBR process in the Moorhead plant.

A review on biological pathogens used in treatment facilities has been carried out by Okoh et.al[8]. The use of micro-organism is very common in treatment facilities. In trickling filters the microorganisms in the wastewater attach themselves to the bed (also known as the filter media), which is covered with bacteria. They emphasized the need to understand the negative environmental impacts posed by the untreated or inadequately treated wastewater entering the nearby ecosystems, especially on the lives that depend on the ecosystem for sustenance. Dermou et. al. constructed a pilot-scale trickling filter and tested for biological chromium(VI)removal from industrial wastewater[9].The study was carried out in three modes namely batch, continuous and sequential batch reactor(SBR) with recirculation. The pilot-scale trickling filter consisted of a Plexiglas tube, 160 cm high and 9 cm i.d. The support material was gravel with a mean diameter of 5.5 mm, and specific surface area of 1059 m^2/m^3, while the depth of the support media was 143 cm and the filter porosity 0.4. They achieved removal rate of about 0.5 kg Cr(VI)/m^2 d. It was concluded that SBR operation with recirculation was a very effective operating mode, since it ensures even wetting of the filter and distribution of the precipitates all over filter volume. Application of biological filtration was studied by Kandasawamy et.al.[10]. Biofiltration was observed to be efficient method for waste treatment.Their study also emphasized that the maintenance of microorganisms in treatment facility is very important factor. While carrying out Biomass detachment by any method like backwashing, loughing and grazing, erosion of biomass may occurs. So biomass loss during the process also needs to be studied.

Lopes and Ferreira used recent multiphase models in order to investigate the hydrodynamic behaviour of a Trickle-Bed Reactor(TBR) in terms of pressure drop, liquid holdup and catalyst wetting efficiency[11].Computational Fluid Dynamics(CFD)model predicts hydrodynamic parameters with reaction conditions quite well. They developed Eulerian k-fluid model resulting from the volume averaging of the continuity and momentum equations. It was solved for a 2D representation of the bed at unsteady state. It was concluded that Eulerian k-fluid model was a rational choice for flow simulation in packed beds. Numerical studies of catalyst wetting and total organic carbon reaction on environmentally based trickle-bed reactors were carried out by Lopes and Ferreira[12]. Their work was devoted to the computational fluid dynamics (CFD) simulation of trickle-bed reactors (TBRs) with environmentally based applications on advanced wastewater remediation technologies. They used high-strength phenolic wastewaters for the catalytic wet oxidation for a case study to evaluate axial profiles of temperature and total organic carbon depletion rates. Also the theoretical calculations were compared against experimental data taken from a TBR pilot plant. The CFD simulation has shown very promosing results in this regard.The investigation on the influence of gas density on total external liquid hold-up, pressure drop and gas-liquid interfacial area, under trickle-flow conditions, and the transition to pulse flow was carried out by Wammes and Westerterp[13].In their study, a gas phase component A was absorbed into a liquid phase, where it reacted irreversibly with a liquid phase component B. It was observed that under gas-liquid trickle-flow conditions, hysteresis behaviour can occur because of imperfect wetting of the surface. When the gas densities are high, transition between trickle-flow and pulse-flow regimes takes place at higher liquid throughputs and therefore the operating region for trickle flow becomes larger. As a first approximation, they used results obtained at low densities for area calculations. It was concluded that it was possible to extrapolate the results for higher diameters.

In their investigation, Uraz and Atalay investigated catalytic wet air oxidation of wastewater that contains organic matter (phenol) in a laboratory scale trickle-bed reactor[14]. The aim of their study

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

was to determine the optimum operating conditions for the reaction of phenol in the wastewater with oxygen using a catalyst. They used industrial copper chromate catalyst. They studied the effects of temperature, gas flow rate, liquid space velocity and initial concentration of phenol on the conversion of phenol at constant pressure and the effect of pressure on the conversion of phenol at constant temperature. With increasing temperature, pressure, gas flow rate and liquid space velocity, the phenol conversion increased and it decreased with increasing initial concentration of phenol. It was observed that copper placed in the structure of the catalyst, mixed with the liquid stream during the reaction. Chirwa and Smit studied simultaneous Cr(vi) reduction and phenol degradation in a trickle bed reactor system[15].They achieved chromium reduction by a mixed culture of Cr(VI) reducing bacteria isolated from activated sludge from the wastewater.It was started in a mixture of phenol and glucose to acclimate the bacteria to phenol toxicity. After that it was supplied with with phenol as a sole carbon source in a trickle bed reactor system. The removal achieved was 70 percent for chromium and 80 percent for phenol. It was concluded that biotreatment was economical alternative to chemical treatment of heavy metals. Patterson used peat bed filters for on-site treatment of septic tank effluent[16]. As a treatment mechanism for reducing the impact of septic tank effluent (STE), addition of a bed of peat, approximately 600 mm deep on the receiving environment (land or water) has been shown to be significant. The aerobic environment was maintained by regular dosing of a Biogreen^{TM} peat filter through a pressurised distribution system. Results showed that faecal coliforms (FC) have been reduced by 99.46%, total nitrogen (TN) by 44.2% and total phosphorus by 83.6%. Young and Chisti reviewed the bioreactor applications in wastewater treatment[17].They presented an overview of bioreactor applications in treatment of gaseous, liquid and solid wastes with emphasis on newer technologies. In their review they discussed various biotreatment technologies. The review also emphasized the importance and applications of trickle reactors in waste treatment. Peng and Hu used immobilized trickle beds in series for continuous recovery of citrates from lignocellulosic waste through sewage leaching[18].They used artificial cellulose waste, after drying, pulverizing and blending. The microoraganisms were acclimated by recycle culture medium. The bed (I) was having cellulosic waste with spores and aspergillas niger and rizopus chinesis. The second bed , bed(II) was having citrate producing strain.The feed was added with 20 I.U. of penicillin and 0.1 mg fluorocitrate per ml of effluent, before entering reactor (II). The citrate was recovered as calcium citrate, by addition of satutated calcium chloride. The chemical oxygen demand was reduced by 88 percent . Total 0.18 eq/l acid was obtained and citrate contributed to 8 g/l. The percentage recovery of 38 percent was obtained for citric acid.A research on performance of trickle bed reactor and active carbon in the liquid phase oxidation of phenol was carried out by Gabbiye et.al.[19].Their study focused on the assessment of key engineering aspects such as reactor start-up, gas-liquid flow directions and effects of temperature, pressure, phenol feed concentration and liquid flow rate on activity and stability performance of unsupported active carbon for trickle-bed reactor and active carbon catalyst to catalytic wet air oxidation of phenolic pollutants. Their study showed that there was need of some promising options for improvement of catalyst stability.

Hambali et. al investigated the textile wastewater decolorization performance using marasmius sp. in immersion and trickling systems[20].They used pilot plant scale bioreactors to observe the best support configuration and modus operandi. An Indonesian white rot fungi namely Marasmius sp. grown on palm oil fibers was used throughout the study. The operation variables were support configurations, i.e. 2 and 3 beds, and modus operandi, i.e. trickling and immersion systems. The wastewater from a textile mill was used in research as sample effluent. It was observed that the most significant decolorization process occured after 5 days and 14 days in the trickling system and immersion system, respectively. It was observed that decolorization process occurs not only due to enzymatic reaction, but also adsorption of the dye to the immobilization media. It was also seen that trickling system gives faster rate of decolorization process (5 days) compared to immersion system (2 weeks).Carsky and Mbhele used immobilized marine algae for heavy metal treatment of wastewater[21]. Their study was aimed at investigating the adsorption characteristics of marine algae on copper solution as an alternate cheaper option with emphasis on its adsorption efficiency, stability and regeneration. The copper removal was studied with respect to the parameters like pH, initial metal concentration,biosorbent size, contact time, temperature and the ability of the biomass to be regenerated in sorption-desorption experiments. The maximum copper uptake of 30 mg of copper / g of biomass was observed.The corresponding operating conditions were 100 mg /L, 0.1 g of biomass, pH 4

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

and at temperature of 250C. It was also observed that copper uptake is increasing with increase in pH, with optimum being pH 4. They also observed that 60 percent removal was observed in first 25 minutes, indicating fast kinetics of removal. The high efficiency of biosorption and elution, low biomass damage and stability over a prolonged operation were few aspects of this methods, making it very effective alternative for copper removal from effluent.

Shrivastava and Majumdar have studied novel biofiltration methods for treatment of heavy metals[22]. They concluded that there was a high possibility for effective application of biofilters for removal of toxic heavy metals from contaminated water in large scale. The success in microbial cloning technique may improve the removal efficiency and hence the reduction in treatment cost. Gangadhara et. al. have carried out research on Biofiltration of Cu (II) using acclimated mixed culture developed from activated sludge[23]. They used mixed culture obtained from the sewage treatment plant for the bioremediation of heavy metal ion (copper) ions. They developed a biofilter column for the removal of copper ions. Microbial species present in the sludge sample were isolated and identified for the bioremediation of Cu (II)ions. The sludge was mixed with equal amount of distilled water. It was then allowed to settle at room temperature in order to remove the supernatant and the sludge. This first settling was carried out in order to remove the dissolved impurities from sludge and the second settling was carried out to collect microbial culture in the supernatant. The result showed 91.5% removal of copper ion was possible for 40 mg/l of inlet concentration of copper. Blecken et al. worked on heavy metal removal by stormwater biofilters and invesigated the effect of drying and subsequent rewetting on the retention of heavy metals[24]. They prepared a biofilter column with top layer, 400 mm, sandy loam, with vegetation (seven plants per column of Carexappressa R.Br. (Tall Sedge), Bottom layer, 400 mm, fine sand, Transition layer, 30 mm, coarse sand, drainage layer, 70 mm, fine gravel, with an embedded drainage pipe at the bottom which leads to a sampling outlet. They found that extended drying caused decreased metal removal from stormwater. However, even after drying of up to seven weeks, between 70% and 90% of metals were removed in the filter. Most importantly, the effect of drying could be minimised for Cu and even eliminated for Pb by a permanent submerge. Ali has studied removal of heavy metals from synthesis industrial wastewater using local isolated candida utilis and aspergillus niger as bio-filter[25]. They preapered biomass media of Candida Utilis which isolated from food sample and Aspergillus Niger which isolated from soil and it was used for biosorption of heavy metals from synthesis industrial wastewater. Two bio-filters were designed with height 10 cm, diameter 3cm and layer with thickness of 2 cm was arranged inside cylindrical Persepx. The first layer of 5.6 g Candida Utilis biomass was spread on the surface sponge and the second filter layer was used with 6g Aspergillus Niger.They studied various parameters like pH, residence time andflow rate. The optimum removal efficiency of chromium, lead, and nickel were 89%, 90%, and 91% for Aspergillus Niger bio-filter, while it was 81%, 83%, 80% for Candida Utilis bio-filter at pH 6, residence time 10 min, flow rate 9 ml/min.

Conclusion

The trickling filter processes are very efficient in handling many types of water pollutants. COD removal upto 90 percent and nitrogen removal upto 99 percent was achieved in various researches. The removal of heavy metals like copper, lead and nickel was reported to be around 90 percent by using suitable microorganisms. The trickle bed was used also for recovery of citrate. The wastewater from mining , textile and other industries has been treated successfully for removal of various pollutants. It can be concluded that the trickling filter systems provides very feasible and economical alternative for wastewater treatment. Various modifications are possible and are being explored for making this operation more economical and efficient.

References

1. *Hassimi Abu Hasan, Siti Rozaimah Sheikh Abdullah, Siti Kartom Kamarudin and Noorhisham Tan Kofli, " A Review On The Design Criteria Of Biological Aerated Filter For Cod, Ammonia And Manganese Removal In Drinking Water Treatment ",* Journal - The Institution of Engineers, Malaysia ,Vol. 70, No.4,pp.25-34, 2009.
2. *Bruce E. Logan, Slawomir W. Hermanowiz, Denny S. Parker, "A Fundamental Model for Trickling Filter", Journal Water Pollution Control Federation , pp.1029-1032, 1987.*
3. *Davood Nourmohammadi, Mir-Bager Esmaeeli,Hossein Akbarian, and Mohammad Ghasemian, "Nitrogen Removal in a Full-Scale Domestic Wastewater Treatment Plant with Activated Sludge and*

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

Trickling Filter", Journal of Environmental and Public Health,Vol. 2013, pp.1-5, 2013.

4. *S. A. R. Ahmed ," Fast-track evaluation of a compact chemically enhanced-trickling filter system",Braz.J.Chem.Eng. vol.24, no.2,pp.1 -5, 2007.*
5. *Husham T. Ibrahim, He Qiang, Wisam S. Al-Rekabi and Yang Qiqi, "Improvements in Biofilm Processes for Wastewater Treatment", Pakistan Journal of Nutrition, VOl.11, No.8, pp. 610-636, 2012.*
6. *Khantong Soontarapa and Nuntachai Srinapawong,"Combined Membrane-Trickling Filter Wastewater Treatment System", J. Sci. Res. Chula. Univ., Vol. 26, No. 2,pp. 59-71, 2001.*
7. *HalisSimsek,Jae-Bom Ohm," Biodegradable Dissolved Organic Carbon in Trickling Filter and Activated Sludge Wastewater Treatment Plants", Digital* Proceeding Of THE ICOEST'2013-Cappadocia, Nevshehir, Turkey.
8. *Anthony I. Okoh, Emmanuel E. Odjadjare, Etinosa O. Igbinosa and Augustina N. Osode, "Wastewater treatment plants as a source of microbial pathogens in receiving watersheds", African Journal of Biotechnology, Vol. 6 , No 25, pp. 2932-2944, 2007.*
9. *E. Dermou, A. Velissariou, D. Xenos, D.V. Vayenas, "Biological chromium(VI) reduction using a trickling filter", J Hazard Mater., VOl. 11, NO. 1-3, pp.78-85, 2005.*
10. *J Kandasamy, S. Vignesawram, T.T.L. Hoang,D.N.S. Choudhary, "Adsorption and Biological Filtration in Wastewater Treatment", Water and Wastewater water Technologies, Encyclopedia of Life Support Systems,(http:/www.eolss.net/Eolss-sampleAllCHAPTER.aspx)*
11. *Rodrigo Lopes and Rosa M. Quinta-Ferreira, "CFD Modelling of Trickle-Bed Reactors for Wastewater Treatment", 17th European Symposium on Computer Aided Process Engineering – ESCAPE17, pp.1-6,2007.*
12. *Rodrigo J. G. Lopes and Rosa M. Quinta-Ferreira,"Numerical Studies of Catalyst Wetting and Total Organic Carbon Reaction on Environmentally Based Trickle-Bed Reactors",* Ind. Eng. Chem. Res., *2010, Vol. 49, No. 21), pp 10730–10743,2010.*
13. *Wino J.A. Wammes and K. Roe1 Westerterp,"Hydrodynamics in a Pressurized Cocurrent Gas-liquid Trickle-bed Reactor",Chem.Eng. Technol.,Vol.14,pp 406-413,1991.*
14. *Canan Uraz, Süheyda Atalay,"Liquid Phase Catalytic Oxidation of Aqueous Solutions That Contain Organic Matter in a Trickle-Bed Reactor", Engineering,Vol.5,pp.39-43,2013.*
15. *Evans M.N. Chirwa and Ernst H.R. Smit, "Simultaneous Cr(Vi) Reduction And Phenol Degradation In A Trickle Bed ReactorSystem",*WISA 2010 conference proceedings,Durban(*www.ewisa.co.za/literature/files/54_7%20Chirwa.pdf)*
16. *Robert A. Patterson, Ken Davey and Nick Farnan,"Peat Bed Filters For On-Site Treatment Of Septic Tank Effluent", Conference On. Advancing On-site Wastewater Systems,25-27th September 2001,University of New England, Armidale,2001.*
17. *Murray Moo-Young and Yusuf Chisti, "Bioreactor applications in waste treatment", Resources, Conservation and Recycling, Vol.11, pp.13-24,1994.*
18. *Robert Y. Peng, Alan Y. Hu,"Sewage Leaching With Immobilized Trickle Beds In Series Used In Continuous Recovery Of Citrate From Lignocellulosic Solid Waste",Journal of Chinese Institute of Environmental Engineering, Vol.1, No.1, pp.63-68,1994.*
19. *Nigus Gabbiye,Josep Font,Agusti Fortuny,Christophe Bengoa,Azael Fabregat, Frank Stuber, "Performance of Trickle Bed Reactor and Active Carbon in the Liquid Phase Oxidation of Phenol", International Journal of Chemical Reactor Engineering,Vol.8,No.1,pp.1-5,2010.*
20. *H. C. Hambali, E. Suwito, S. H. Suhardi and T. Setiadi,"Textile Wastewater Decolorization performance using Marasmius sp. in Immersion and Trickling Systems", Proceeding The 3rd IWA ASPIRE Conference & Exhibition, Taiwan,October 18-22, 2009, pp.151.*
21. *M. Carsky and F.N. Mbhele, "Adsorption of heavy metals using marine algae", South African Journal of Chemical Engineering, vol. 18, no. 2, pp 40-51,2013 .*

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

22. *Srivastava NK, Majumder CB.,"Novel biofiltration methods for the treatment of heavy metals from industrial wastewater.", J Hazard Mater., Vol.151, No.1,pp 1-8, 2007.*
23. *Gayathri Gangadhara, Subhajit Majumderb, Smita Raghuvanshic, Suresh Guptad, "Biofiltration of Cu (II) Using Acclimated Mixed Culture",Proceedings of Technological Advancements in Chemical and Environmental Engineering (TACEE-2012),Department of Chemical Engineering, BITS-Pilani, Pilani Campus, India, May 23-24, 2012..*
24. *Godecke-Tobias Blecken, Yaron Zinger, Ana Deletic Tim Fletcher, Maria Viklander, "Heavy metal removal by stormwater biofilters:can it withstand alternative wetting and drying conditions?,"11th International Conference on Urban Drainage, Edinburgh, Scotland, UK, 2008.*
25. *Safaa Abd Alrasool Ali, "Removal Of Heavy Metals From Synthesis Industrial Wastewater Using Local Isolated Candida Utilis And Aspergillus Niger As Bio-Filter", The International Journal of Biotechnology, Vol.2 NO.5,pp.83-90,2013.*

Author Biblography

Mrs. Sonali R. Dhokpande

Mrs. Sonali R. Dhokpande has completed her Masters in Food Technology from Nagpur University in 2003. She is working as Assistant Professor in Chemical Engineering Department of Datta Meghe College of Engineering, Airoli, Maharashtra, India.She has published and presented five international papers. Her area of interest includes food technology and biological treatment for various pollutants.

Email:srdhokpande@gmail.com

Mr. Sunil J. Kulkarni

Mr. Sunil J. Kulkarni has completed his Masters in Chemical Engineering from Tatyasaheb Kore Institute of Engineering and Technology, Warananagar. He is working as Assistant Professor in Chemical Engineering Department of Datta Meghe College of Engineering, Airoli, Navi Mumbai, India. He has published 13 international review and research papers and presented 15 research papers in international conferences. His area of research includes adsorption, environmental engineering. He is on the reviewer board of many international journals and reviewed many international papers.

Email:suniljayantkulkarni@gmail.com

Dr. Jayant P. Kaware

Dr.Jayant Prabhakarrao Kaware, male, Chemical Engineer, pursued his education from Laxminarayan Institute of Technology, Rashtra Sant Tukdoji Maharaj Nagpur University. He was Professor-in-charge for the Biodiesel Research Laboratory associated with the department of chemical engineering.He was Member of Board of Studies for Chemical & Polymer Technology at Sant Gadge Baba Amravati University since 2000 and Chairman from 2008 till 2012. He is a Member of Academic Council since 2005 in the University. He has published more than 36 research papers. He is working on various policy making government bodies related to biodiesel.

Email:jayantkaware@gmail.com