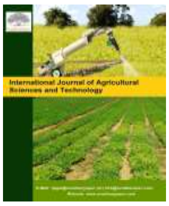
SvedbergOpen
DISSEMINATION OF KNOWLEDGE

International Journal of Agricultural Sciences and Technology

Publisher's Home Page: https://www.svedbergopen.com/



Research Paper Open Access

Impact of TSS and Seasonal Variation on Characterization of Wastewater With COD Profile of French Fries Processing Industry and Its Role in Sustainable Development

Amit Kumar Tiwari[1], Vijay Kumar Upadhyay[2*] and Arun Agarwal[3]

[1]Research Scholar, Department of Civil Engineering, Uttaranchal University, Dehradun, India. E-mail: er.atiwari@gmail.com
[2]Associate Professor, Department of Applied Science and Humanities, Tulas Institute, Dhool Kot, Dehradun, Uttarakhand, India 221206. E-mail vkupadhyay2005@gmail.com
[3]Professor, Department of Civil Engineering, Uttaranchal University, Dehradun, Uttarakhand, India 248007. E-mail: blasterarun@gmail.com

Article Info

Volume 4, Issue 2, November 2024
Received : 02 June 2024
Accepted : 19 October 2024
Published : 05 November 2024
doi: 10.51483/IJAGST.4.2.2024.33-41

Abstract

The aim of this study is to know the impact of Total Suspended Solids (TSS) and seasonal variation on Chemical Oxygen Demand (COD) values and characterization of untreated composite sample of wastewater of potato French fries processing industry. The wastewater parameters covered in this study are pH, biochemical oxygen demand (BOD 3 at 270C), COD and TSS. The impact of seasonal variation on wastewater quality of potato were studied and found that COD and TSS in increasing order as potato becomes older as compared to the fresh crop. This study shows the relation between COD and TSS after coagulation flocculation process in lab scale. The process of coagulation and flocculation is conducted without changing the pH (increase or decrease) of the wastewater by using polymer 459 (Cationic coagulant – solution of inorganic basic salt of chloro aluminium) and Setfloc 81 (Flocculant /polyelectrolyte, Anionic Acrylamide polymer) as a flocculant. The TSS values reduced in range of 71% to 75% which were contributing to the range of 32% to 50% of total organic load in terms of COD. The COD, BOD 3 at 270C, and TSS increased up to 31.68%, 40.11%, 43.18% and 5.03% respectively with time as the potato becomes older due to storage as compared to the fresh potato used for the processing. The COD analysis pre and post starch recovery of wastewater of cutter process was studied separately. Specific to the wastewater of cutter process the COD value reduced in range of 72% to 78% after starch recovery. The TSS removal reduced the organic load as COD up to 50% after coagulation flocculation which will require minimum energy footprint for maintaining dissolved oxygen supposed to be supplied by power driven surface aerators and will reduce CO2e reduction with minimum wastewater treatment cost. The type and quality of the potato were not studied in this report.

Keywords: *Wastewater, Potato processing, Physico-Chemical, Organic load, TSS, COD*

1. Introduction

Wastewater of the food industry is a particular problem, due to the presence of significant amounts of organic components (Jolanta and Rajewska, 2017). The market research states very fast growth in potato processing industries. The potato

* *Corresponding author: Amit Kumar Tiwari, Associate Professor, Department of Applied Science and Humanities, Tulas Institute, Dhool Kot, Dehradun, Uttarakhand India 221206. E-mail vkupadhyay2005@gmail.com*

processing industries are water and energy intensive industries which generate huge quantities of organic wastes in terms of wastewater including starch in it and potato peels. Wastewater characteristics of potato processing plant depends on the processing method. In general, the following steps are applied in potato processing: washing the raw potatoes; peeling, which includes washing to remove softened tissue; trimming to remove defective portions; shaping, washing, separation; heat treatment (optional); final processing or preservation; and packaging (Hung *et al.,* 2006).

High-water consumption in potato processing industries generates wastewater containing high BOD_5 and COD values up to 7000 mg/l; O_2 and 10000 mg/l; O_2; respectively (Justina Catarino *et al*., 2007). Wastewater from the potato processing industry contains high concentration of chemical oxygen demand (COD) caused by the presence of starch and protein (Gautam Neha *et al*., 2017). Food industries produce large quantities of effluent wastewater which is characterized by high concentration of organic pollutants. Wastewater disposal from the industry deteriorate the quality of environment and utilization of its energy potential in terms of biogas will not be accounted (Manhokwe *et al*., 2015). Wastewater of potato processing industry has starch content, nutrients, potato fine particles, waste ingredients and fibers in majority which contribute for high COD load and having strong potential and can play important role in sustainable development with respect to by product starch (Cai Tongbo *et al*., 2019) and protein recovery (Takeguchi Masayuki *et al*., 2015) i.e., waste to economy, waste to energy- Biogas (Antwi Philip *et al*., 2017) and CO_2 emission reduction in aerobic and anaerobic wastewater treatment process.

This paper is focused on Characterization of composite samples taken from Equalization tank. The equalization tank is a tank where the wastewater of all the processes (i.e., Potato washing, peeling, cutting, and blanching), and other supporting activities like utilities (Boiler Blow down, cooling tower blow down) get collected and mixed. Relation between TSS and COD of untreated wastewater is established along with the impact of seasonal variations on physicochemical characteristics of untreated wastewater, COD of high polluting processing steps like peeler, cutter and blancher, COD value of cutter wastewater before starch recovery and post starch recovery.

This paper will help to researchers, process engineers and professionals to find out the organic load profile of French fries processing industry with big size of data which will be helpful in taking decision for cost effective treatment process selection, segregation of highly polluting wastewater stream, waste to economy by starch recovery, energy recovery by anaerobic treatment of the wastewater and CO_2 emission reduction in aerobic treatment process by reducing the organic load by removing the TSS. The wastewater of cutter selected for starch recovery based on the visual observation of insoluble white starch get settled in wastewater samples.

1.1. Potato Processing Description

There is various type of potato products available in the market like Frozen French fries, Chips, dehydrated mashed potatoes, dehydrated diced potatoes, potato flake, potato starch, potato flour and other potato frozen foods. The product selection decides the selection of processing units involved in potato processing industries (Hung *et al*., 2006). The processing step involve following stages; Quality check of potatoes which include the segregation of desirable potato tubers is based on the following factors: solids and specific gravity, shape, size, color, and visual defects (Costa *et al.,* 2011), Destoning, Sorting and Grading of potatoes, The sorting is carried out manually by trained staff who observe, identify, and segregate the undesirable qualities of potato. After sorting healthy, high qualities of desirable potatoes, these are graded into various sizes (Ugonna, *et al.,* 2013). **Washing of Potatoes and Mud Removal:** The performance evaluation of the washing process depends on the quality of the raw water used in this process. This is because water might be a source of microbial contamination (Siddique *et al.,* 2017). Thus, Moreover, the washing efficiency of root crops can be determined using water turbidity measuring device (AI-Katary *et al.,* 2010).

1.2. Potatoes Peeling and Deskinning

Peeling potato is process of removing the skin which normally protects it from flesh or pulp thereof. Three different types of peeling methods are reported: thermal peeling, chemical peeling, and mechanical peeling (Talodhikar V.P. *et al.,* 2017). The peel waste and wastewater separated through screens (Hung *et al.,* 2006). The performance evaluation of machines can be done in terms of machine capacity, peeling efficiency, operational cost and cost benefit ratio (Singh, 2017).

1.3. Trim Table

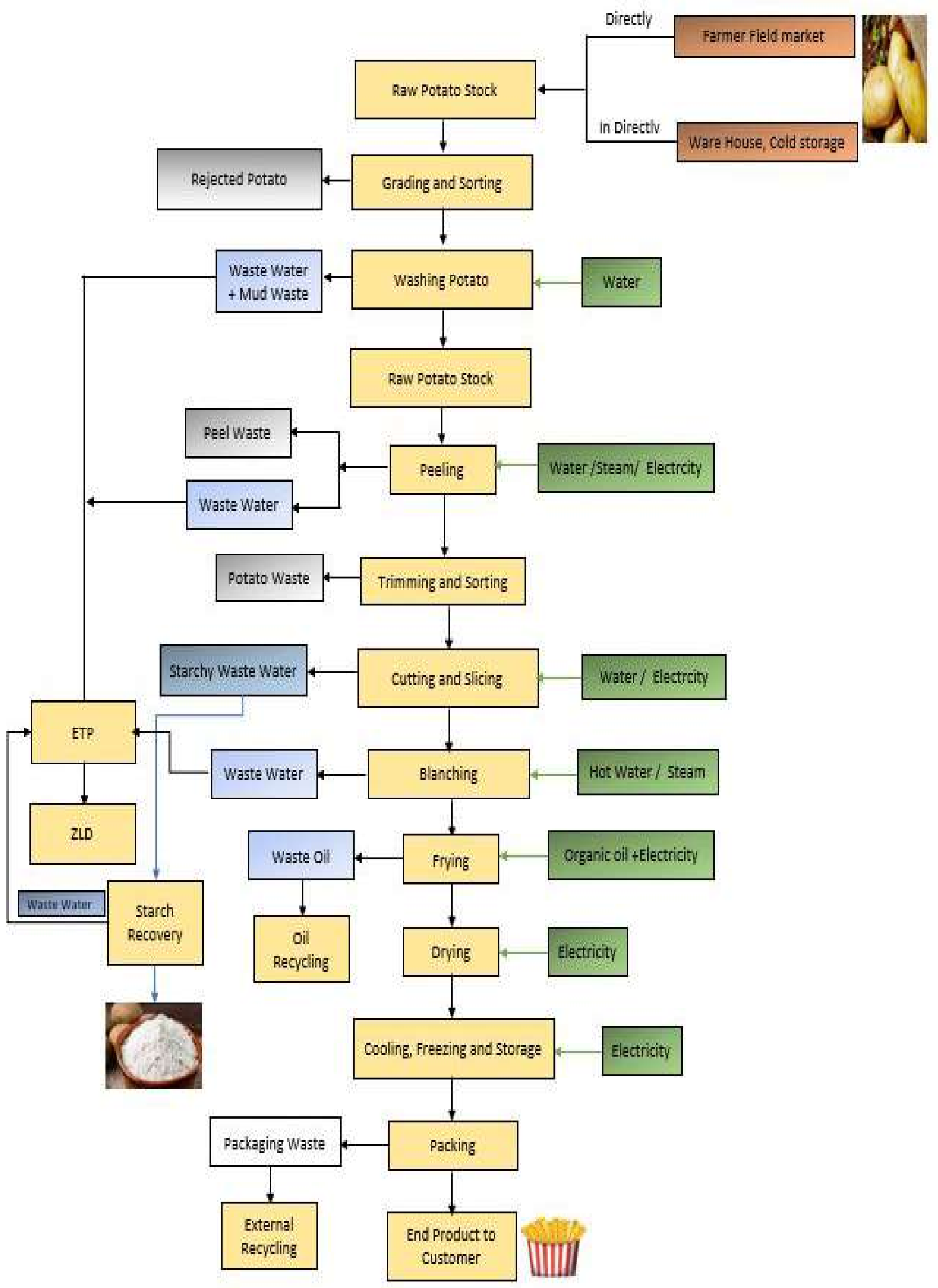
Trim table is an inspection conveyor used for manual inspection of foreign material, defect removal and trimming of potatoes.

1.4. Pulse Electrical Field (PEF)

The purpose of PEF application is cell disintegration, structure modification, reduction of turgor pressure (osmotic pressure) as a result a better cutting quality, higher cutting yields, smoother surfaces, less oil absorption, no feathering, and less breakage. The pulse electric field causes tiny pores in the potato cell walls, also known as cell permeabilization which facilitates cutting, blanching, drying, and frying processes (Diaz-Razola *et.al.,*2023).

1.5. The Peeling, Cutting and Blanching

Process generate wastewater of higher organic load in terms of COD, BOD and TSS, with starch content. The starch content, fine potato particles, fibers release in wastewater from potato processing during peeling, cutting and blanching process.



Flowchart 1: Flow Diagram of French Fry Processing' with Inputs and Outputs Resulting Product

2. Methodology

A. Sample Collection: The composite sample taken from the wastewater collected in equalization tank. The equalization tank has the wastewater generated from entire manufacturing process like peeling, cutting, blanching, cleaning in place (CIP) of Machineries, cleaning, washing, Cooling tower and Boiler blow down. The composite sample of wastewater collected each day of every month of operations days. Other than this, wastewater streams samples collected separately generated from peeler, cutter and blancher considering as high COD wastewater stream.

B. Method of Sample Analysis: "APHA" standard methods for the examination of water and waster water, 23rd Edition – 2017 were used to analyze the sample as per following method.

1. **pH:** IS 3025 (Part 11): 1983 (RA 2002)
2. **BOD:** IS 3025 (Part 44): 1993 (RA 2014)
3. **COD:** APHA (23rd Edition): 2017, 5220 B Open reflux Method
4. **TSS:** IS 3025 (Part 17): 1984 (RA 2017)

All values are in mg/l except pH.

C. Chemical preparation for polymer 459 as coagulant and Set floc 81 as a flocculant: 1 g of Polymer 459 dissolved in 100 ml of distilled water and 0.1 g of Set floc 81 dissolved in 100 ml to prepare the solution. 1 liter of wastewater used for coagulation flocculation process in laboratory. Set the Dose of polymer 459 solution by adding 15ml and set floc solution added 1 ml which was constant for all the wastewater samples.

3. Results and Discussion

In this study the composite sample of wastewater generated from manufacturing processes and other supporting activities like utilities (Boiler Blow down, cooling tower blow down), wastewater from recycling plant, floor washing, utensil cleaning and washing, equipment cleaning and washing on daily basis from January 2022 to December 2022.

An average pH was found in the range of 4.50 to 4.70 throughout the year. Slight variation in pH value of 4.5 to 4.7 i.e., 4% to 5% observed started from April onwards in Figure 1. The pH values of peeler wastewater found in range of 4.2 to 4.5, pH values of cutter wastewater found in range of 4.5 to 4.8 and pH values of blancher found in range 4.8 to 5.0. The pH values of wastewater of composite sample and segregated streams found below 7 indicate that no chemical process involved for peeling of potatoes. The pH values reported by other researchers are 7.5, 8.2 and 10 for washing, peeling, and cutting activity respectively (Anbuselvi, 2018). The pH 4.9 was also reported by Manhokwe *et al.* (2015) which is meeting the range of pH of the existing study. The alkaline pH represents that peeling activity is done with the help of caustic. The pH value is 6.54 for the wastewater after cutting and soaking processes is also reported by other researcher closer to this study. The pH of wastewater is dependent upon type of peeling process i.e., Thermal peeling, chemical peeling, and mechanical peeling (Talodhikar *et al.,* 2017). The pH towards higher side upto 11.1 indicate that selected potato peeling process is chemical peeling involving the alkaline solution or medium (Terry L Hagin, 1972). The pH value reported in the range of 6.5 to 8.5 by Hung *et al.* (2006).

In this study the COD values were found in the range of 6732 mg/l to 9854 mg/l, i.e., 31.68% increase till November from January which is reported in Figure 1. The COD values increased continuously from February onwards. It is the fact that COD value of wastewater influenced by potato processing methods and quantity of water used in the process, storage time of potato and quality of the potato. The COD value reported in range of 6732 mg/l to 9854 mg/l when wastewater of all the processing stage including wastewater of utilities get dilute in equalization tank. There is a great difference found in the COD value of wastewater generated from cutter after starch recovery. In this study the reduction in COD value post starch recovery from the cutter found in range of 72 to 77% of its initial value. The COD of cutter wastewater found in range of 26445 mg/l to 40968 mg/l which reduced to in range of 7212 mg/l to 9356 mg/l after starch recovery (Figure 4). The COD of wastewater streams generated from cutter, pillar and blancher in this study are considered as High COD containing wastewater streams. The wastewater generated from cutter has the highest COD because of potato starch content released in this wastewater streams during the cutting process reported in Figures 4 and 5. The COD values of wastewater reported in Figures 1-5 represent the complete profile of COD of wastewater streams generated in potato French fries processing industries.

The COD value reported by other researchers is 76 mg/l, 10000 mg/l and 11700 mg/l for washing, peeling and cutting activity respectively (Anbuselvi, 2018). The COD value of cutting and soaking process of potato processing industry reported as 7230 mg/l (Gautam Neha *et al.,* 2017). The starch rich wastewater sample resulted from the process lines where potatoes are sliced and washed having the COD values in range of 3864 mg/l to 9272 mg/l (Jolanta and Rajewska, 2017). The COD value of wastewater after starch by product recovery found 7000 mg/l and 10000 mg/l (Justina Catarino *et al.*, 2007). The COD value of potato processing wastewater reported 6000 mg/l (Hegdea Swati *et al.*, 2018) and 6769 (Manhokwe *et al.*, 2015). The COD value of Peka Kroef plant reported as 7500 mg/l and of Uzay Guda plant 4500 mg/l (Zoutberg *et al.*, 1999).

The TSS values in the wastewater of equalization tank found in range of 1705 mg/l to 2898 mg/l i.e., around 41.16% increase till November as compared to the TSS value of January month reported in Figure I. The highest TSS was found in range of 7118 mg/l to 8840 mg/l in the wastewater samples taken from cutter processing reported in Figure VI which is comparative study of TSS of wastewater of peeler, cutter and blancher process. The TSS values increased continuously from February onwards. The used water in the process is an important factor which either concentrates to TSS or dilutes the TSS load present in wastewater (Hung *et al.*, 2006). In this study the TSS value of wastewater from peeling, cutting and blanching processes were found in range of 3860 mg/l to 6200 mg/l 7118 mg/l to 8840 mg/l and 1216 mg/l to 1643 mg/l respectively. The TSS value reported in range of 1705 mg/l to 2898 mg/l when wastewater of all the processing stage including wastewater of utilities get diluted and mixed in equalization tank. The similar observation of TSS values 5000 mg/l, 6800 mg/l and 8250 mg/l were reported respectively for washing, peeling, and cutting activity respectively by Anbuselvi (2018). The starch rich wastewater sample resulted from the process lines where potatoes are sliced and washed having the TSS values found in range of TSS values in range of 1027 mg/l to 1584.7 mg/l (Jolanta and Rajewska, 2017). The TSS value decreases after starch by product recovery (Justina Catarino *et al*., 2006). The TSS values vary in wastewater samples collected in different months of the year (Terry L Hagin, 1972) which is similar to the observation of this study. It is observed that suspended solid has great influence on COD values reduction in range of 32% to 50% in coagulation flocculation process.

The BOD values found in range of 1500 mg/l to 2505 mg/l which is around 40% increase in October and November month as compared to the BOD value of January month reported in Figure I. The BOD values increased continuously in most of the samples from February onwards. The BOD values 4000 mg/l, 6600 mg/l and 8200 mg/l were reported respectively for washing, peeling, and cutting activity respectively (Anbuselvi, 2018). The BOD value decreases and reported 7000 mg/l after starch by product recovery (Justina Catarino *et al*., 2006). The BOD values vary in wastewater

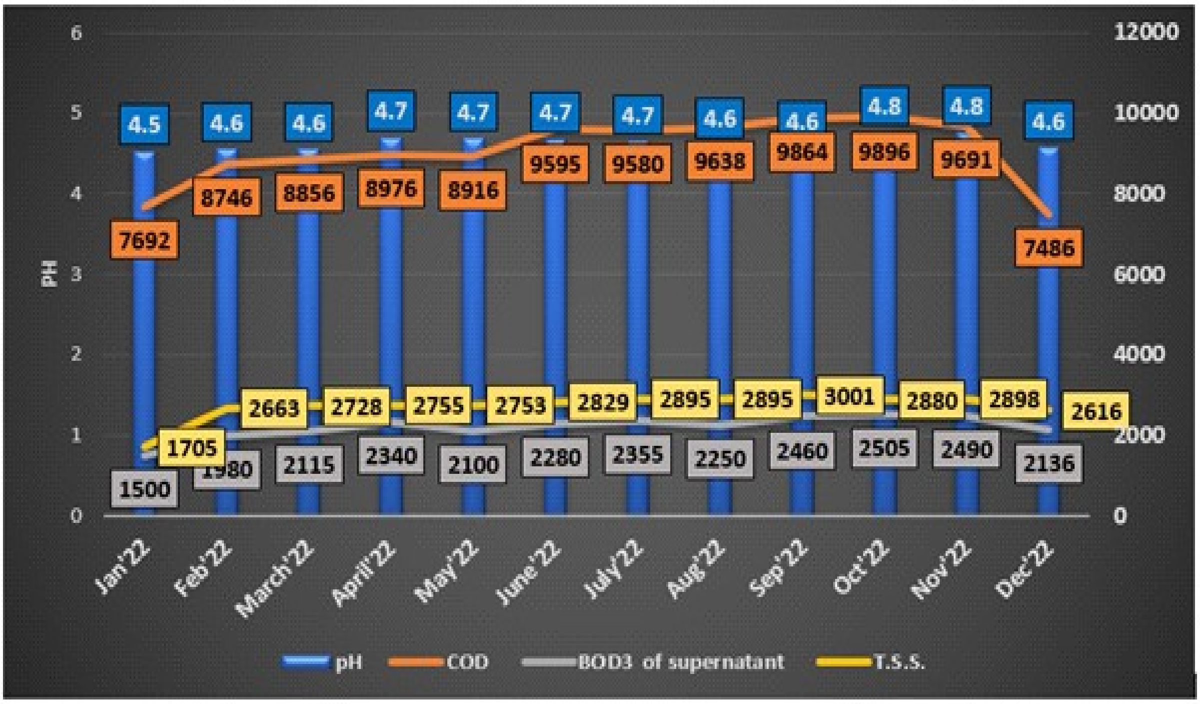


Figure 1: pH, COD, BOD and TSS Values of Composite Sample of Untreated Wastewater from Equalization Tank. All Values are in mg/l Except pH

samples collected in different months of the year (Terry L Hagin, 1972).

Impact of TSS and seasonal variation on COD Value: As the TSS values increased with the time of older potato the COD load increased as mentioned in Figure I. Increase in COD with increasing of TSS indicates that TSS mostly is organic in nature because potato fine particles, potato fibers and insoluble starch content in the wastewater. As the TSS removed in coagulation flocculation processes the COD values drastically reduced in range of 32% to 50% presented in Figure 2. The TSS, BOD and COD values are in ascending series with month and season as the potato becomes older as mentioned in Figure 1. The TSS removal from 72% to 75% reducing the COD load in range of 32% to 50% indicate that

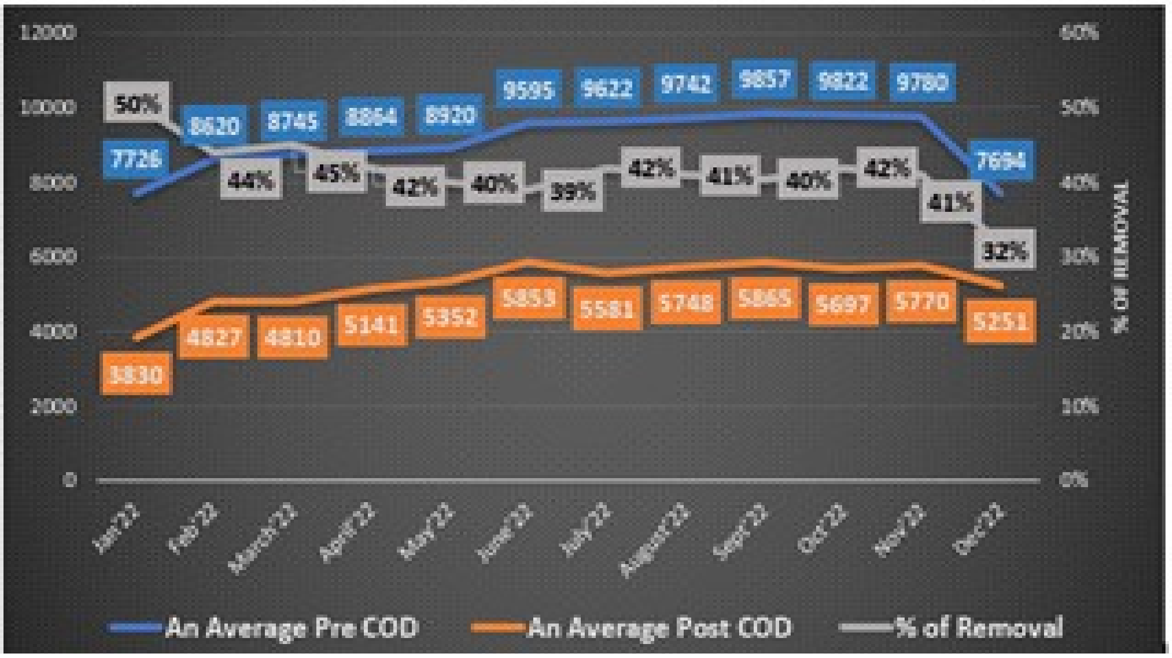


Figure 2: An average COD Value (An Average of 4 Samples in Month) of Wastewater Pre and Post Coagulation and Flocculation with COD % Removal

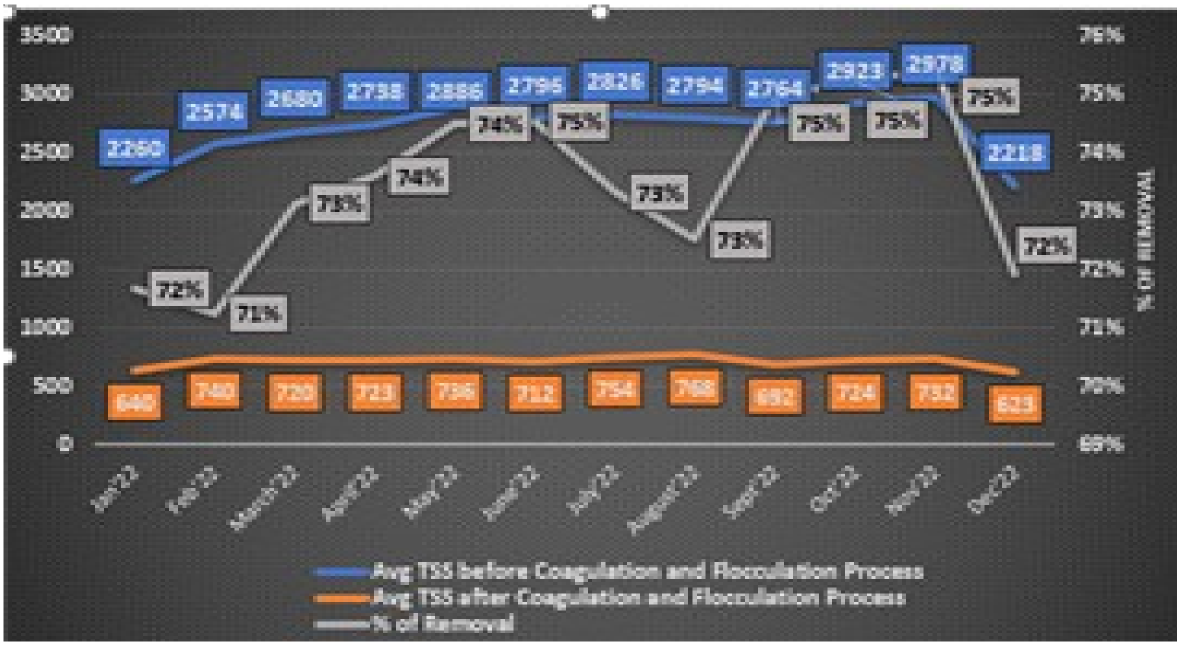


Figure 3: An average TSS Value (An Average of 4 Samples in month) of Wastewater Pre and Post Solid Settling with Percentage of TSS Removal

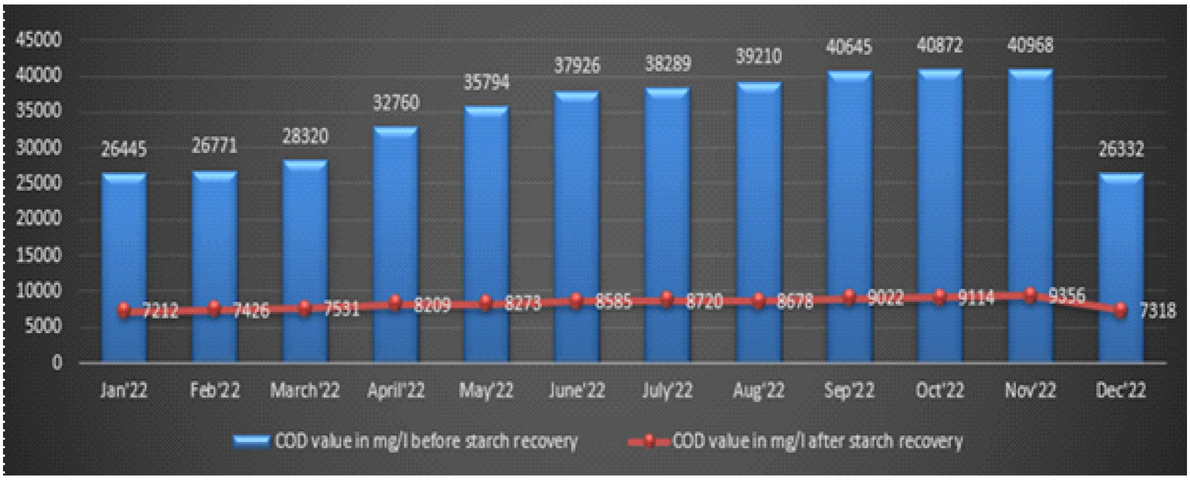


Figure 4: COD Value of Wastewater of Cutter Process Pre and Post the Starch Recovery

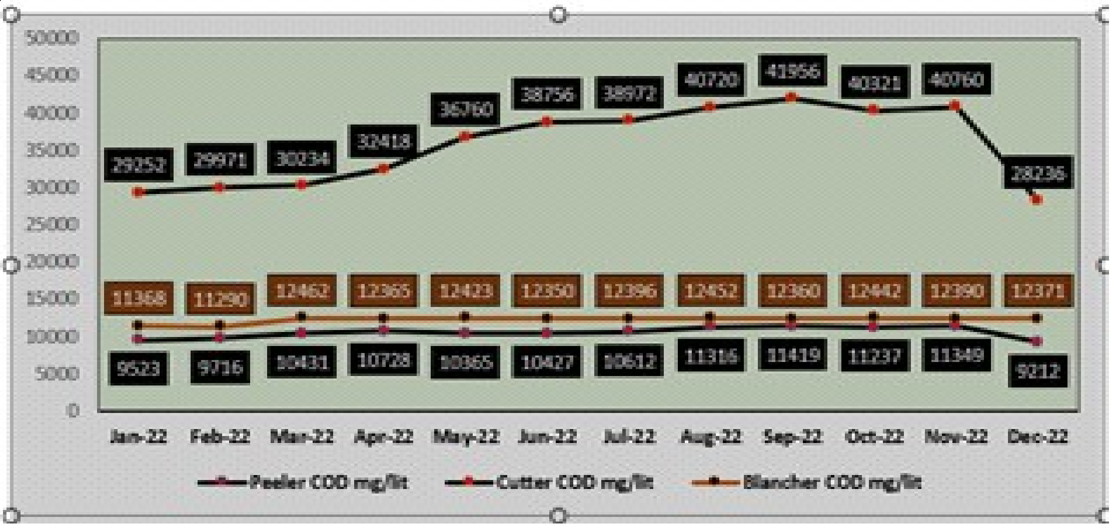


Figure 5: Comparative study of High COD Containing Wastewater of Peeler, Cutter, and Blancher

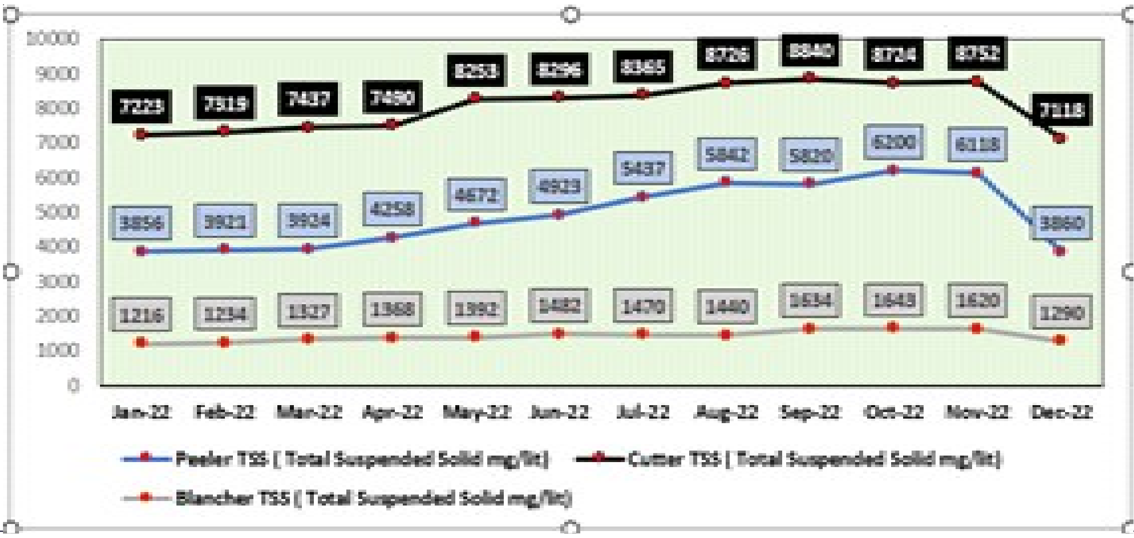


Figure 6: Comparative Study of TSS Values of Wastewater of Peeler, Cutter, and Blancher

TSS contributing the COD load.

4. Conclusion

The COD, BOD_3, TSS and pH of wastewater samples taken from equalization tank increased up to 31.68%, 40.11%, 43.18% and 5.03% respectively with time as the potato become older till month of November due to storage as compared to the fresh potato used for the processing. The high COD containing wastewater generates from peeling, cutting and blanching process in which the wastewater of cutter is characterized as highest COD loaded wastewater. The COD value of wastewater of cutter process reduced in range of 72% to 78% after starch recovery. The highest TSS was found in range of 7118 mg/l to 8840 mg/l in the wastewater samples taken from cutter processing. The pH of the wastewater peeler, cutter and blancher found in range of 4.5 to 5.5.

The TSS removal from wastewater of equalization tank after mixing all the wastewater of all the processes is observed in range of 72% to 75% without changing the pH in coagulation flocculation process which reduced the organic load in terms of COD in range of 32 % to 50%. This reduction in COD indicates this much lower oxygen demand supposed to be supplied by power operated surface aerators or diffused aeration system in aerobic biological treatment process. This lower organic load will require minimum energy footprint during aerobic biological treatment process of wastewater and will reduce CO_2 emission with minimum treatment cost. This scientific approach will lead to sustainable development with respect to the waste to economy by starch recovery and waste to energy by selecting anaerobic treatment process for biogas production and peel waste utilization method generates in peeling process.

The important factor in determining the characteristics of wastewater is the quantity of water used in the process which has ability to either dilute or concentrate the organic loading in the wastewater. The quantity of water used in each process was not measured in this study.

The outcome of this study should enable possibilities for future research to conduct the study about establishing the relation between potato type, potato quality with respect to starch and sugar content in it, potato cutting type and quantity of the water used during the processing. Proper selection of wastewater treatment technologies by highlighting the specific characteristics of the potato processing wastewater and utilization of the peel waste generates during potato peeling process are the points of attention in potato processing industry for determining its role in sustainable development.

References

AI-Katary H.S., Abd El-Mawla H.A., Osman M.A. and Ahmed A.M. (2010). Washing Water Turbidity as Indicator to Fruit and Vegetable Washer Efficiency. *Misr J. Agric. Eng*., 27(2), 662-675.

Anbuselvi, S. and Albenna, Reji. (September–October 2018). Extraction of Starch from Potato Processing Wastewater and Its Effect on Growth of Plants. *Research Journal of Pharmaceutical, Biological and Chemical Sciences (RJPBCS)*, 9(5) 1211. ISSN: 0975-8585

Andrew D. Eaton, *et al*. (2017). APHA "Standard Methods for the Examination of Water and Wastewater, 23rd Edition".

Antwi Philip, Li Jianzheng, En Shi, Portia Opoku Boadi and Ayivi Frederick. (2017). Modelling Biogas Fermentation from Anaerobic Digestion: Potato Starch Processing Wastewater Treated Within an Up flow Anaerobic Sludge Blanket. *Journal of Bioremediation and Biodegradation*, 8, 2.

Cai Tongbo, Lin Hua, Liu Zhaojun, Chen Kaiwei, Lin Yi, Xi Yuan, Chhuond Kong. (2019). Starch Wastewater Treatment Technology, *IOP Conf. Series: Earth and Environmental Science*, 022054.

Costa, C., Antonucci, F., Pallottino, F., Aguzzi, J., Sun, D.W. and Menesatti, P. (2011). Shape Analysis of Agricultural Products: A Review of Recent Research Advances and Potential Application to Computer Vision. *Food and Bioprocess Technology*, 4, 673-692.

Díaz Carmen Razola, Tylewicz Urszula, Rocculi Pietro, Verardo Vito. (2023). Chapter Eight - Application of Pulsed Electric Field Processing in the Food Industry. *A Volume in Unit Operations and Processing Equipment in the Food Industry*, 257-298.

Gautam Neha, V.S. Sapkal and R.S. Sapkal. (2017). Production of Bio-ethanol from Potato Processing Wastewater using Membrane Technology. *International Conference Proceeding ICGTETM*. doi: http://doi.one/10.1727/IJCRT.17168 , 379-389.

Gautam Neha, V.S. Sapkal and Sapkal, R.S. (2017), Production of Bio-ethanol from Potato Processing Wastewater using Membrane Technology. *International Conference Proceeding ICGTETM*, ISSN: 2320-2882, http://doi.one/10.1727/IJCRT.17168. 379-389

Hegdea Swati, Jeffery S. Lodgeb and Thomas A. Trabolda. (2018). Characteristics of Food Processing Wastes and Their Use in Sustainable Alcohol Production. *Renewable and Sustainable Energy Reviews,* 81, 510-523.

Hung Yung-Tse and Howard H. Lo and Adel Awad and Hana Salman. (2006). Potato Wastewater Treatment, Universidad de Sao Paulo (USP) (CRUESP), 193-254.

Jolanta Janiszewska and Rajewska Paulina. (2017). The Possibility for the Use of Ultrafiltration for the Treatment of Potato Processing Wastewater. *Journal of Machine Construction and Maintenance*, 4(107), 131-139.

Justina Catarino, Elsa Mendonc, Ana Picado, Ana Anselmo, Jo~ao Nobre da Costa, and Paulo Partida´rio. (2007), Getting Value From Wastewater: By-Products Recovery in a Potato Chips Industry. *Journal of Cleaner Production*, 15(2007), 927-931.

Manhokwe, S., Parawira, W. and Zvidza,i C. (2015). Aerobic Mesophilic Treatment of Potato Industry Wastewater. *International Journal of Water Resources and Environmental Engineering*, 7(7), 92-100.

Siddique G., Aleem A., Hussain G. and Raza H.A. (2017). Development and Performance Evaluation of Carrot Washer. *Journal of Global Innovations in Agricultural and Social Sciences*, 5(1), 28-31. https://doi.org/10.22194/JGIASS/5.1.772

Singh K. Vijay (2017). Testing and evaluation of Pedal Operated Potato Peeler. *International Journal of Agricultural Engineering*, 10(2), 465-467.

Takeguchi Masayuki, Hasumi Fumihiko, Mayanagi Masatsugu and Satou Masaaki. (2015). Utilization of Potato Protein Recovered from Wastewater of Potato Starch Factory as Cattle Feed. *J. Eng. Technol. Sci*., 47(2), 170-178.

Talodhikar, V.P., Gorantiwar, V.S. and Dhole, L.P. (2017). Mechanization & Development of Potato Peeling Machine: A Review. *International Journal of Engineering and Innovative Technology (IJEIT),* 6(9), March.

Terry L. Hagin (1972). A Study of the System Treating Potato Processing Wastes at Fairfield Products Inc., Clark. A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science, Major in - Civil Engineering, South Dakota - State University.

Ugonna C.U., Jolaoso M.O. and Onwualu A.P. (2013). *International Research Journal of Agricultural Science and Soil Science,* 3(8), 291-301. ISSN: 2251-0044.

Zoutberg R George and Eker Zerrin. (1999). Anaerobic Treatment of Potato Processing Wastewater. *Water Science and Technology*, 40(1), 297-304.

Cite this article as: Amit Kumar Tiwari, Vijay Kumar Upadhyay and Arun Agarwal (2024). Impact of TSS and Seasonal Variation on Characterization of Wastewater With Cod Profile of French Fries Processing Industry and Its Role in Sustainable Development. *International Journal of Agricultural Sciences and Technology*. 4(2), 33-41. doi: 10.51483/IJAGST.4.2.2024.33-41.