DOI https://doi.org/10.5281/zenodo.10049652#310

TWIST, 2024, Vol. 19, Issue 4, pp. 46-52

TWIST

Journal homepage: www.twistjournal.net

Textile Wastewater Treatment by Newly Introduced Natural Adsorbents

Prof. Dr. Arun Kanti Guha*
Department of Textile Engineering, Southeast University, Dhaka 1208, Bangladesh
[**Corresponding author*]

Miraz Mehedi
Department of Textile Engineering, Southeast University, Dhaka 1208, Bangladesh

Rajib Saha
Department of Textile Engineering, Southeast University, Dhaka 1208, Bangladesh

Abstract
A large quantity of water is consumed in wet processing units of textiles causing generation of huge wastewater. Wastewater needs proper treatment before discharge to water bodies. Several treatment methods are used in textile sector in different types of effluent treatment plants (ETPs). Those are physicochemical, biological, biochemical and electrochemical consisted of primary, secondary and tertiary treatments. Effluent treatment by using any type of ETP is costly for its high initial fixed amount and annual operating cost. It is mandatory to treat effluent before discharge. The low cost method like treatment with natural absorbents could be useful method as an alternative of conventional methods. This work was done to implement this low cost concept for textile wastewater treatment. Several easily obtainable natural plants were used in this work. All treated plants reduced 22-33% pH after 48h treatment. Treated plants reduced 26-70% color after treatment with wastewater indicates that these are good adsorbents of color. Medicinal aloe (*Aloe vera*) was capable to reduce 12.6% COD whereas water spinach (*Ipomoea aquatic*), malabar spinach (*Basella alba*) and cauliflower (*Brassica oleracea*) reduced 22-82% BOD load. Cauliflower and medicinal aloe reduced 26.4% and 55.2% iron from wastewater respectively.

Keywords
Textile wastewater, Treatment, Natural adsorbent, Pollution reduction

INTRODUCTION

The wet processing units of textiles use a large quantity of water. After processing huge quantity of wastewater is generated globally and it needs proper treatment before discharge. For example, 1500 billion litre ground water was used for dyeing and washing fabrics in a year (Guha et al., 2015). 217 million m^3 waste water was generated for 1.80 million metric ton fabric production (Hossain et al., 2018). The waste water generated from textile wet processing units is harmful for environment. A summary of characterization of textile waste water is listed in the following table.

Table 1 Summary of textile waste water characterization (Dey & Islam, 2015)

Parameter	Reported Values
pH	3.9-14
TDS (mg/L)	90.7 – 5980
DO (mg/L)	0-7
COD (mg/L)	41-2430
BOD (mg/L)	10-786
TSS (mg/L)	24.9-3950

From the above Table 1, it was understood that the wastewater generated from textile wet processing units is harmful because this wastewater consists of toxic chemicals and deep color. In Table 2, a comparison on textile wastewater quality was done between Bangladesh and other countries.

Table 2 Comparison of textile wastewater between Bangladesh and other countries (Dey & Islam, 2015)

Parameter	China	India	Pakistan	Bangladesh
pH	9-13	4.8-9.3	8-14	3.9-14
COD (mg/L)	1800-2000	725-2080	182-2430	41-2430
BOD (mg/L)	400-500	243-1842	117-786	10-786
SS (mg/L)	250-350	270	49-471	24.9-3950

Wastewater needs proper treatment before discharge to water bodies. Several treatment methods are used in textile sector globally in different types of effluent treatment plants (ETPs). Those are physicochemical, biological, biochemical and electrochemical consisted of primary, secondary and tertiary treatments (Khan et al., 2009).

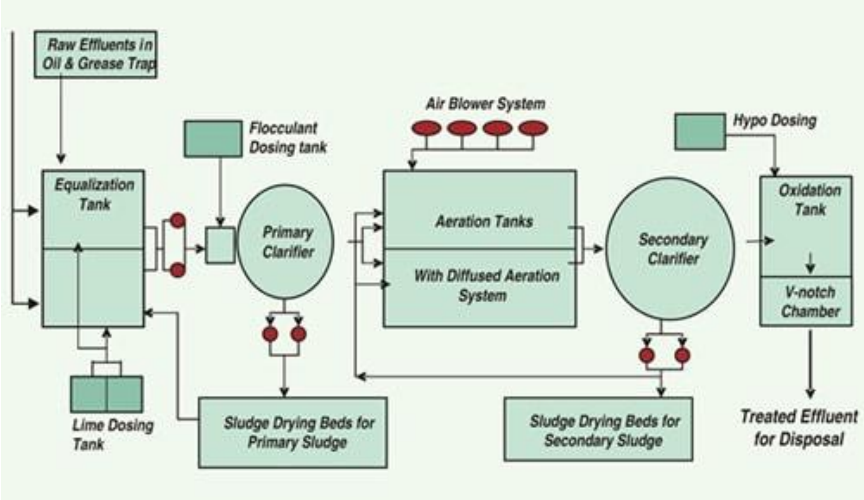


Fig. 1 A block diagram of Biochemical ETP used in Textiles

As per recent study, it was found that textile industry needs a lot of money to install and operate ETPs perfectly (Hossain, 2019).

Table 3 Installation, operation and management costs of different types of ETPs of various textile industry

Sl.	Name of Industry	Type of ETP	Capacity (m^3/h)	Installation fixed investment (USD$	Operating cost (US$)
1	Square Fashion Limited	Biological	50	235,000	39,639.55
2	Newtex Composite Textile Ltd	Physicochemical	110	116,000	188480.85
3	Le Nouveau Tex (Pvt.) Ltd.	Electrochemical	50	298,778.59	78,464.91

The wastewater treatment by using any type of ETP is costly for its high initial fixed amount and annual operating cost. It is mandatory to treat effluent before discharge. Low cost method like treatment with natural absorbents could be useful method as an alternative of conventional methods. A comprehensive literature review was done. As per our literature survey, In a previous report, authors (Morais et al., 1999) reported that eucalyptus bark could be used as adsorbent for removal of reactive dyes from Textile wastewater. In a paper (Annadurai et al., 2002)., author reported a method to use low cost banana and orange peels for adsorption of dyes from aqueous solution. Authors reported that favorable pH was alkaline in this work. Based on experimental results it was found that banana peel was more effective than orange one. Gupta and coworkers (Gupta et al., 2009) reported a detail review paper. Authors covered most of the works in this paper published from 1980 to 2007. In most of the papers activated carbon was used as adsorbent. But natural plants were not found to use as adsorbent for wastewater treatment but some other natural waste such as orange peel was found to use as adsorbent. In a previous paper published from this group (Guha et al., 2013) reported the method of removal of pH and TDS by using several plants, water hyacinth, water lily and bark of plantain plant (banana). Authors found that these natural absorbents wer suitable to absorb pollutant from textile effluent. Shamra and coworkers reported a method for removal of heavy metal ions from wastewater using low cost *Pyras pashia* (Sharma et al., 2020). Authors (Elsakkaa et al., 2024) reported use of sawdust and sugarcane bagasse as low cost adsorbent in wastewater treatment. Authors reported that, recent global trend turned to focus on using of low-cost methods for wastewater treatments.

As per literature survey, it was observed that some natural adsorbents, *Pui shak* (English name: Malabar Spinach, Scientific name: *Basella alba*), *Kolmi shak* (English name: Water Spinach, Scientific name: *Ipomoea aquatic*), *Palong shak* (English name: Spinach, Scientific name: *Spinacia oleracea*) and *Fulkopi* (English name: Cauliflower, Scientific name: *Brassica oleracea*) were not used previously to treat industrial wastewater. Use of these natural adsorbents could be a new and cost effective approach for textile wastewater treatment.

In this work, above mentioned plants were used to treat textile wastewater as natural adsorbents to establish low cost textile wastewater treatment method. Several physicochemical parameters such as, pH, TDS, TSS, COD, BOD, color and heavy metals were measured before and after treatment of textile wastewater. The aim of this study is to use new natural absorbents for textile wastewater for development of low cost treatment method.

EXPERIMENTAL

Adsorbent collection

Natural adsorbents (plants), *Pui shak* (English name: Malabar Spinach, Scientific name: *Basella alba*), *Kolmi shak* (English name: Water Spinach, Scientific name: *Ipomoea aquatic*), *Palong shak* (English name: Spinach, Scientific name: *Spinacia oleracea*) and *Fulkopi* (English name: Cauliflower, Scientific name: *Brassica oleracea*)), *Kochuripana* (English name: Water Hyacinth, Scientific name: *Eichhornia crassipes*) and *Ghritkumari* (English name: Medicinal Aloe, Scientific name: *Aloe vera*) were collected from local market. Both of stems and leaves of *Pui Shak*, *Kolmi Shak*, *Palong Shak*, *Fulkopi* and *Kochuripana* were used for wastewater treatment. In case of *Aloe vera*, leaves with gel were used for wastewater treatment.

Textile wastewater collection

Samples of textile wastewater were collected in clean and dry plastic bottles from a textile industry of Bangladesh. After collection, samples of untreated effluent sent to BCSIR, Dhaka for testing. Untreated samples were brought to the laboratory of the department of textile engineering of Southeast University, Tejagaon, Dhaka for treatment of natural plants.

Adsorbent treatment

Each plant was washed before use. Washed plant was chopped perfectly. 100g plant was treated with 500mL untreated wastewater under closed condition and kept 48 hour. After 48 hour treatment, treated plants were filtered out by using simple filtration process. After filtration treated samples were sent to Bangladesh council of scientific and industrial research (BCSIR) Laboratories Dhaka, Bangladesh following standard method for analysis.

Measurement of pH and Total Dissolved Solids (TDS)

pH and total dissolved solids (TDS) were measured before and after treatment of collected wastewater samples in the laboratory of the department of textile engineering of Southeast University by using portable pH (model: HI96107, Hanna Instruments, China) and TDS (model: HI9830, Hanna Instruments, China) meters. Both of pH and TDS meters were calibrated before measurement.

Measurement of color

Textile wastewater consists of huge coloring materials. The wastewater comes out after dyeing contains unused dyestuff with different colors. These colors should be removed by proper treatment. If these colors are not removed, different water bodies will be colored which will change natural characteristics of water stream. In this work, colors of untreated and treated wastewater samples by natural plants were measured in BCSIR laboratories, Dhaka following COLORMRTRIC method which is an approved method by American Public Health Association (APHA) (APHA Website, reference 12).

Measurement of COD and BOD

Both of chemical oxygen demand (COD) and biological oxygen demand (BOD) are very important physicochemical parameters of wastewater characterization. COD is measured by addition of potassium dichromate in acidic solution to the wastewater. It takes few hours to complete the experiment. Both of COD and BOD are pollution indexes contributed by wastewater. These two physicochemical parameters estimate quantitatively the presence of organic substances could be oxidized in wastewater samples. Microorganisms are essential for BOD measurement. Both of COD and BOD are mentioned in this study were measured at BCSIR laboratories, Dhaka by following standard test procedure of APHA (5220.B).

Measurement of TSS

Total suspended solids of both of untreated and treated wastewater samples were measured at BCSIR laboratories, Dhaka following standard test procedure of APHA (2540.D).

Measurement of heavy metals

There are different heavy metals are present in textile dye stuff such as cadmium (Cd), chromium (Cr), iron (Fe) and lead (Pb). After processing, heavy metals remain in wastewater those are harmful for human being as well as aquatic lives. Heavy metals were measured before and after treatment of wastewater samples in the same laboratory following APHA suggested test procedure (3111.B).

RESULTS AND DISCUSSION

pH

pH is an important parameter for characterization of textile effluent. pH of both of untreated and treated effluent samples were measured. All the pH values are summarized in the following table.

Table 4 pH of textile wastewater samples before and after treatment

Sl.	pH of untreated wastewater before treatment	pH obtained after 48 h treatment	Reduced pH (%)	Remark
1	9.7	With *Basella alba* 6.6	32.0	pH is reduced in every case.
2		With *Ipomoea aquatic* 6.6	32.0	
3		With *Spinacia oleracea* 7.3	24.7	
4		With *Brassica oleracea* 7.6	21.6	
5		With *Eichhornia crassipes* 7.5	22.7	
6		With *Aloe vera* 6.5	33.0	

As per experimental results (Table 4), pH of untreated wastewater was 9.7 which was alkaline in nature. After 48h treatment of wastewater with different natural plants as absorbents pH values of treated wastewater lowered to almost neutral value (7) which was favorable for aquatic environment. It should be noted that no reported value of treated wastewater with four natural absorbents, *Basella alba, Ipomoea aquatic, Spinacia oleracea and Brassica oleracea* was found in literature.

But reported pH values were available with *Eichhornia crassipes* and *Aloe vera*. In a previous report (Guha et al., 2013) from our group we found that 5.48% pH value reduced after 48h treatment with *Eichhornia crassipes*. In that case, pH of untreated effluent was 7.3 and corresponding pH value after 48h treatment was 6.9. In that case the nature of untreated effluent was almost neutral, so rate of reduction was relatively lower. Treatment of natural absorbent with high pH is more appropriate to explain its effective treatment capability. So this plant again used in this work to find out better condition. In another report (Muruganandam et al., 2017). *Aloe vera* gel was used for coagulation purpose. But in this work both of leaf and gel of *Aloe vera* were used to reduce pH of untreated effluent.

Color

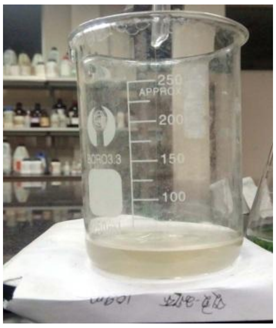
Quantitative values of color of both of untreated and treated wastewater samples were measured in BCSIR laboratories, Dhaka, Bangladesh by following standard test procedure (APHA, COLORMRTRIC). All the values are summarized in the following table.

Table 5 Experimental values of color obtained before and after treatment of textile effluent

Sl.	Color of untreated wastewater before treatment (PCU)	Color obtained after 48 h treatment (PCU)	Reduced (%)	Remark
1	2032	With *Basella alba* 1476	27.4	Color reduced after 48h treatment.
2		With *Ipomoea aquatic* 1496	26.4	
3		With *Spinacia oleracea* 1423	30.0	
4		With : *Brassica oleracea* 1782	12.3	
5		With *Eichhornia crassipes* 611	69.9	

From above results, it was clearly understood that newly introduced natural adsorbents (plants) were capable to reduce color of effluent after treatment. From above data it is found that 12.3-69.9% color was reduced after 48h treatment of untreated textile effluent with different adsorbents. In a previous report, a natural plant, *Calotropisgingantea* was used to remove color from textile effluent effectively (Balaji et al., 2015).

Before treatment



After 48h treatment with *Basella alba*

Fig. 2 Representative images of color reduction of textile wastewater after 48h treatment

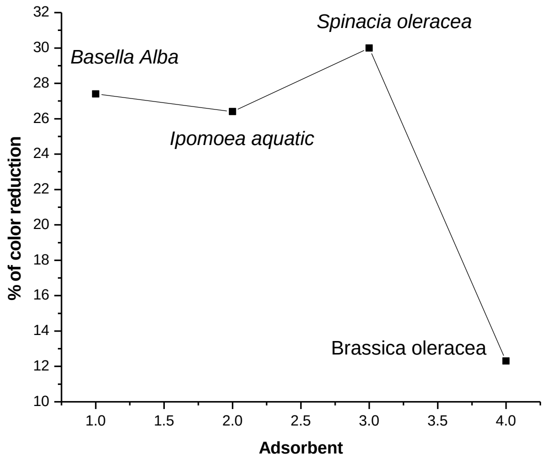


Fig. 3 A plot of % of color reduction *vs.* adsorbent

Chemical Oxygen Demand (COD)

Quantitative values of chemical oxygen demand (COD) of both of untreated and treated wastewater samples were measured.

Table 6 Experimental values of COD obtained before and after treatment of textile wastewater

Sl.	COD of untreated wastewater (mg/L)	COD obtained after 48 h treatment (mg/L)	Reduced (%)	Remark
1	206	With *Eichhornia crassipes* 141	Reduced 31.6	COD reduced after 48h of treatment
2		With *Aloe vera* 180	Reduced 12.6	

Two adsorbents, *Eichhornia crassipes* and *Aloe vera* were capable to reduce COD after treatment. In a reported work, Sajne *(Moringa oleifera*) seed powder and Maize (*Zea mays*) seed powder were used to reduce 21-74% COD from textile wastewater (Patel et al., 2013).

Biological Oxygen Demand (BOD)

Quantitative values of biological oxygen demand (BOD) of both of untreated and treated wastewater samples were measured. All the values are summarized in the following table.

Table 7 Experimental values of BOD obtained before and after treatment of textile wastewater

Sl.	BOD of untreated wastewater (mg/L)	BOD obtained after 48 h treatment (mg/L)	Reduced (%)	Remark
1	302	With *Basella alba* 105	65.2	BOD was reduced significantly after treatment.
2		With *Ipomoea aquatic* 235	22.2	
3		With *Brassica oleracea* 55	81.8	

Brassica oleracea was very suitable adsorbent to reduce BOD from textile wastewater. From the experimental result (Table 7) it was understood that it reduced 81.8% BOD after treatment. *Basella alba* and *Ipomoea aquatic* also reduced BOD 65.2% and 22.2% respectively after treatment. In literature, it was found that natural adsorbent is capable to reduce BOD from textile wastewater (Kabra et al., 2013).

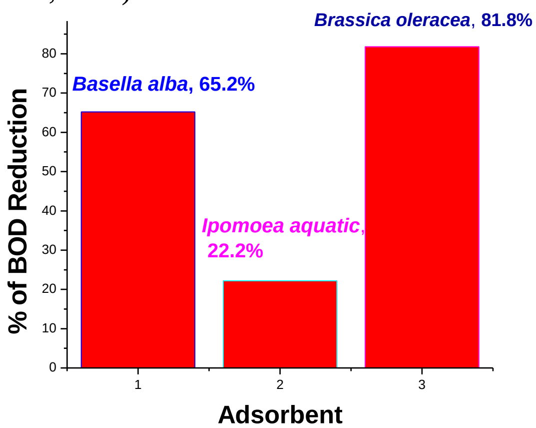


Fig. 4 A bar chart of percentage of BOD reduction *vs.* adsorbent

Figure 4 clearly denotes that *Brassica oleracea* is strongly capable to reduce BOD from textile wastewater after treatment.

Heavy metals

Quantitative values of heavy metals of both of untreated and treated wastewater samples were measured. After analysis of experimental results it was concluded that *Brassica oleracea* and *Aloe vera* reduced 26.4% and 55.2% iron from textile wastewater respectively. Both ionic and molecular forms of heavy metals can be removed by natural absorbents from wastewater (Sharma et al., 2020, Sirisha et al., 2019 and Shooto et al., 2019).

It should be noted that both of TDS and TSS values increased after treatment because of biodegradation of natural adsorbents.

Table 8 A summary of results with respect to capability of reduction of pollutants by different adsorbents

Adsorbent	Physicochemical Parameters	Concentration reduced after 48h treatment (%)
Basella alba	pH	32.0
	Color (PCU)	27.4
	BOD (mg/L)	65.2
Ipomoea aquatic	pH	32.0
	Color (PCU)	26.4
	BOD (mg/L)	22.2
Spinacia oleracea	pH	24.7
	Color (PCU)	30.0
Brassica oleracea	pH	21.6
	Color (PCU)	12.3
	BOD (mg/L	81.8
	Fe (mg/L)	26.4
Eichhornia crassipes	pH	22.7
	Color (PCU)	69.9
	COD (mg/L)	12.6
Aloe vera	pH	33.0
	COD (mg/L)	12.6
	Fe (mg/L)	55.2

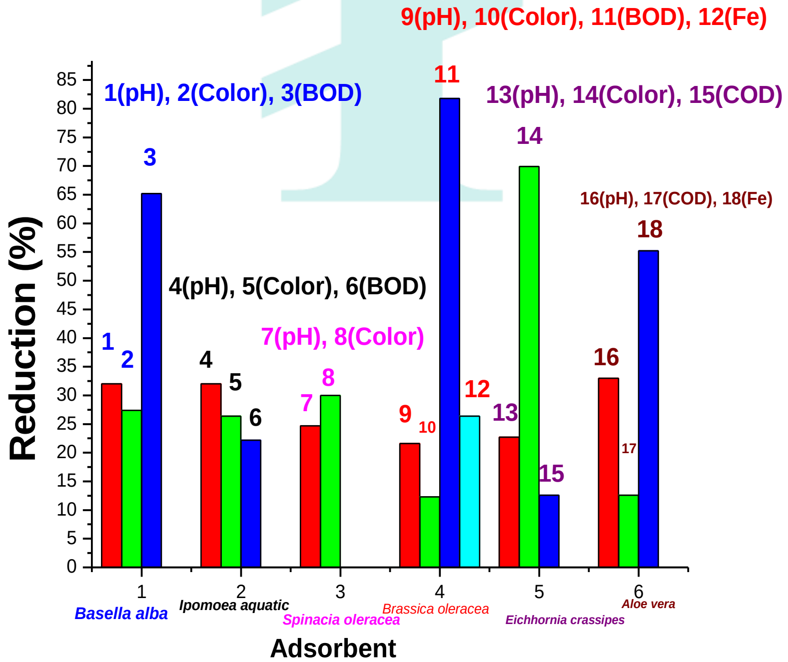


Fig. 5 A bar chart of reduction of different parameters *vs.* adsorbent used in this work

CONCLUSION

Textile wastewater treatment with adsorbents (natural plants) is a good technique. According to experimental results, it is concluded that natural plants, *Pui shak* (English name: Malabar Spinach, Scientific name: *Basella alba*), *Kolmi shak* (English name: Water Spinach, Scientific name: *Ipomoea aquatic*), *Palong shak* (English name: Spinach, Scientific name: *Spinacia oleracea*) and *Fulkopi* (English name: Cauliflower, Scientific name: *Brassica oleracea*), *Kochuripana* (English name: Water Hyacinth, Scientific name: *Eichhornia crassipes*) and *Ghritkumari* (English name: Medicinal Aloe, Scientific name: *Aloe vera*) are suitable to treat with textile wastewater as natural adsorbents. These plants could be used to reduce concentrations of COD, BOD and iron (Fe). These plants are also suitable to reduce pH of untreated wastewater.

ACKNOWLWDGEMENT

Authors are grateful to the management and Institute of Research and Training (IRT) of Southeast University, Bangladesh for their sincere support to complete this project.

FUNDING INFORMATION

This project was funded by Institute of Research and Training (IRT), Southeast University, Bangladesh.

DECLARATION OF CONFLICT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

1. Guha, A. K., Rahman, O., Das, S., & Hossain, M. S. (2015). Characterization and composting of textile sludge. *Resources and Environment*, *5*(2), 53-58.
2. Hossain, L., Sarker, S. K., & Khan, M. S. (2018). Evaluation of present and future wastewater impacts of textile dyeing industries in Bangladesh. *Environ. Dev.*, *26*, 23–33.
3. Dey, S., & Islam, A. (2015). A Review on textile wastewater characterization in Bangladesh. *Resources and Environment*, *5*(1), 15-44.
4. Khan, M. S., Ahmed, S., Evans, A. E. V., & Chadwick, M. (2009). Methodology for performance analysis of textile effluent treatment plants in Bangladesh. *Chemical Engineering Research Bulletin*, *13*(2), 61-66.
5. Hossain, M. A. (2019). Financial analysis of alternative effluent management in textile industry, *Master's Thesis*, Bangladesh University of Engineering and Technology, Bangladesh.
6. Morais, L. C., Frietas, O.M., Goncalkes, E.P., & Vasconcele as, L.T. (1999). Reactive dye removal from wastewater by adsorption on eucalyptus bark, variables that define the process. *Water Research*, *33*(4), 979-988.
7. Annadurai, G., Juang, R.S., & Lee, D.J. (2002). Use of cellulose based wastes for adsorption of dyes from aqueous solution, *J. Hazardous Materials*, *92*(3), 263-274.
8. Gupta, V. K., Carrott, P. J. M., Carrott, M. R., & Suhas, D. (2009). Low-cost adsorbents: growing approach to wastewater treatment—a review. *Critical Reviews in Environmental Science and Technology*, *39*(10), 783–842.
9. Islam, A., & Guha, A. K. (2013). Removal of pH, TDS and Color from textile effluent by using coagulants and aquatic/non aquatic plants as adsorbents. *Resources and Environment*, *3*(5), 101-114.
10. Sharma, H., Kumar, R., Vishwakarma, M. C., Joshi, S. K., & Bhandari, N. S. (2020). Biosorptive removal of Cu(II), Cd(II) and Pb(II) ions from synthetic wastewater using low cost biosorbent (*Pyras pashia*): thermodynamic and equilibrium studies. *Asian Journal of Chemistry*. *32*(4), 727-732.
11. Elsakkaa, E. A., Fouadb, H. A., & Hassanainc, A. M. (2024). The Use of sawdust and sugarcane bagasse as low cost adsorbent in wastewater treatment. *Egyptian Journal of Chemistry*. *67*(3), 117-125.
12. Information available at: https://www.apha.org
13. Muruganandam, L., Kumar, M. P. S., Jena, A., Gulla, S., & Godhwani, B. (2017). Treatment of wastewater by coagulation and flocculation using biomaterials. *IOP Conf. Series: Materials Science and Engineering*, *263*, 032006.
14. Balaji, P., Vignesh, B., Sowmia, M., Meena, M. & Lokesh, L. (2015). Removal of color from textile effluent using natural adsorbent (*Calotropisgingantea*). *International Journal of Innovations in Engineering and Technology*, *5*(4), 265-272.
15. Patel, H., & Vashi, R. T. (2013). Comparison of naturally prepared coagulants for removal of COD and color from textile wastewater. *Global NEST Journal*, *15* (4), 522-528.
16. Kabra, A. N., Khandare, R. V., & Govindwar, S. P. (2013). Development of a bioreactor for remediation of textile effluent and dye mixture: a plant bacterial synergistic strategy, *Water Research*, *47*(3), 1035-1048.
17. Sirisha, P., Sultana, S., & Gopikrishna, P. (2019). Analytical solutions and neural network modelling for removal of chromium (VI) from industrial wastewater using *Carissa carandas*. *Asian Journal of Chemistry*. *31*(7), 1465-1469.
18. Shooto, N. D., & Naidoo, E. B. (2019). Detoxification of wastewater by paw–paw (*Carica papaya L.*) seeds adsorbents. *Asian Journal of Chemistry*, *31*(10), 2249-2256.