The Scientific Temper (2024) Vol. 15 (1): 1759-1763
E-ISSN: 2231-6396, ISSN: 0976-8653
Doi: 10.58414/SCIENTIFICTEMPER.2024.15.1.25
https://scientifictemper.com/

RESEARCH ARTICLE

Investigating physico-chemical characteristics of water and wastewater in the printing industry

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Abstract

Pollution is considered as a critical issue within the Indian printing industry, it has extensive health implications. Investigation of the physico-chemical characteristics of various inputs like water and other resources and residues like wastewater and other discharged chemicals associated with printing processes, aiming to provide a comprehensive understanding of environmental contamination. Rigorous analysis of all effluents during research sheds light on the pollution related to water and their concentrations, emphasizing their potential adverse effects on the industry workforce and surrounding communities. Comprehension related to this major concern among industry stakeholders and regulatory bodies for fostering a collaborative effort towards a cleaner and healthier future of the globe and particularly in Indian printing industry.

Keywords: Water, Wastewater, Total dissolved salts, Chemical oxygen demand, Total suspended solid.

Introduction

Printing industry in India has been facing several significant environmental issues due to its water pollution, noise pollution and chemical usage. Water is essential to the survival and growth of every living thing on earth (Singh *et al.*, 2010). Currently, only Earth is a planet with roughly 70% water (Patil *et al.*, 2012). Environmentalists are under pressure to ascertain the physicochemical properties of natural water resources due to the increased demand for water resulting from population growth and industrial development (Prasanna & Ranjan, 2010). It is among the most significant substances that have a significant impact on life (Sharma *et al.*, 2015). Unwanted changes in the physico-chemical properties of water have put people all over the world in serious danger (Abegunrin, *et al.*, 2016). Industrialization, growing human population, and other human activities have all contributed to the severe pollution of water with many dangerous substances (Kumar & Prabhahar, (2012). Because the human population is susceptible to a variety of water-borne illnesses due to using polluted drinking water, it is imperative that the quality of drinking water be examined regularly (Bharti *et al.*, 2017). High-quality water resources are dependent on several physicochemical properties (Adesakin *et al.*, 2020). These traits can pinpoint specific conditions affecting the ecology of living things and provide sensible approaches to management and conservation (Usharani *et al.*, 2010). A vital component of illness prevention and raising standard of living is the availability of clean water (Lukubye & Andama, 2017).

The Indian printing industry has traditionally played a significant role in supporting various sectors such as publishing, packaging, advertising, and education. It is a diverse sector that includes offset printing, screen printing, flexography printing, and Gravure printing. Offset printing has revolutionized the printing industry, enabling the mass production of high-quality printed materials with remarkable efficiency and precision (Birkenshaw, 1993). Flexography's printing versatility makes it the preferred choice for various applications, including flexible packaging, labels, corrugated cardboard, newspapers, and even textiles. Its ability to accommodate a wide range of substrates and its speed and cost-effectiveness position flexography as a cornerstone in the printing industry (Johnson, 2008). Gravure

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How to cite this article: Sharma, D. K., Vandana, Kumar, P., Pandey, A., Pal, J. (2024). Investigating physico-chemical characteristics of water and wastewater in the printing industry. The Scientific Temper, **15**(1):1759-1763.

Doi: 10.58414/SCIENTIFICTEMPER.2024.15.1.25

Source of support: Nil

Conflict of interest: None.

Received: 22/01/2024 **Accepted:** 15/02/2024 **Published** : 15/03/2024

printing press comprises several integral components that work synergistically to achieve precision and superior print quality. Key components include the engraved cylinder, doctor blade, ink fountain, substrate feed, drying systems, and impression roller (Kumar *et al.*, 2023). Each element plays a crucial role in ensuring the accurate transfer of ink onto the substrate. The exceptional image reproduction capabilities of gravure printing make it a preferred choice for various applications, including high-end publications, packaging, decorative prints, and security printing. Its ability to handle long print runs with consistent quality, intricate details, and vibrant color solidifies its position as a premium printing technology (Bruno, 1982).

The printing industry is a major industry of water consumption, contributing to wastewater and impacting biodiversity. Printing requires a variety of chemicals, pigments, and solvents for ink formulation, cleaning, and equipment maintenance (Jangra, 2016). Analysis of physico-chemical parameters of water and wastewater is a significant aspect. The analysis employed standard methods consistent with APHA (2008) guidelines for the physico-chemical assessment of water and wastewater samples. Effluent standards set by the Central Pollution Control Board (CPCB) in India for water and wastewater in the flexography and gravure printing industries are vital for maintaining environmental quality and ensuring regulatory compliance. Understanding the specifics of several physicochemical parameters such as pH, sulfate, phosphate, total suspended solids (TSS), chemical oxygen demand (COD), and alkalinity that are utilized in water quality testing is essential. Water samples were collected from the selected printing industries for the assessment of critical parameters such as pH, alkalinity, total dissolved salts (TDS), and TSS.

Materials And Methods

Lab and Testing Facilities

Effluents of water and wastewater samples were studied after careful sampling from pre-identified industries in laboratories of Department of Environment Science and Engineering of GJUS&T, Hisar.

Methodology Followed

The water and wastewater samples were collected from four pre-identified printing industries for physicochemical analysis. Standard method for analysis for physico-chemical analysis of samples from print sector with the help of American Public Health Association (APHA, 2008) was done. Composite samples of water and waste water were obtained from printing industries. The samples were put in a 20-liter plastic container that was labeled, sealed, and transferred to the lab where they were kept at 4°C for further examination. Wastewater had an average temperature of 30.7°C during the experimental phase and 36°C during the stabilization phase, respectively.

Table 1: Effluents of water and wastewater

S. No.	*Effluents*	*Standard range*	
		Water	*Wastewater*
1	pH	6.5–8.5	6.5–8.5
2	Alkalinity	20–200 mg/L ($CaCO_3$)	200 mg/L $CaCO_3$
3	Chemical oxygen demand (cod)	--	250–500 mg/L
4	Total dissolved solids (mg/L)	500	2100
5	Total suspended solids (mg/L)	100	100
6	Phosphate	--	5 mg/L.
7	Sulphate	--	500 mg/L

Standard Adopted

Major effluents analysed: for water and wastewater (Table 1).

Selection of Industry

Keeping the nature of study and application guideline for the conduct of such studies, study was carried out in four different printing industries named as P, Q, R, and S. The names of printing industries are kept confidential because workers have consented to take part in the study on this condition that no personal information of their and their industries will be published anywhere else without asking their permission. These printing industries are selected on the basis of their production range. The printing industries which have production range more than 100 tons/year are selected for this study. Sampling was carried out three days a week at intervals of three hours.

Data Analysis

Physico-chemical analysis of water and wastewater was measured of each printing industry. The assessment involved physico-chemical analysis of water and wastewater parameters within the printing industries to determine compliance with established standards of CPCB. Water quality parameters values for the chosen industries were pH (7.1–7.5), alkalinity (62–93 mg/L), TDS (159–190 mg/L), and TSS (45–65 mg/L) as shown in Table 2. Wastewater quality parameters values for the chosen industries were pH (6.9–8.5), alkalinity (388–501 mg/L), COD (400–790 mg/L), TDS (800–892 mg/L), and TSS (312–468 mg/L), phosphate (28 to 48 mg/L) and sulphate (56 to 66 mg/L) as shown in Table 2. Each industry met the CPCB standard's permissible limit in terms of water's pH, alkalinity, TDS, and TSS parameters. In case of wastewater, pH, phosphate and sulphate parameters for wastewater of these printing industries are within CPCB standards.

The physico-chemical characteristics of water and wastewater of pre-identified printing industries P, Q, R and S are shown in Table 2.

Table 2: Range, mean and standard deviation of physico-chemical parameters of water and wastewater in selected P, Q, R, and S printing industries

I	*W/ WW*	*Physico-chemical characteristic of water and wastewater parameter range, mean and Std., n = 05*						
		pH	*A*	*COD*	*TDS*	*TSS*	*P*	*S*
P	W	7.1–7.5 7.3 ± 0.15	88–93 89.6 ± 2.07	––	159–170 167 ± 4.52	45–50 49 ± 2.23	––	–––
	WW	6.8–7.1 7.02 ± 0.1	466–492 477.4 ± 9.37	400–420 414.8 ± 8.43	809–830 813.8 ± 11.49	312–350 330.8 ± 16.5	28–32 30 ± 1.5	64–65 64.4 ± 0.54
Q	W	7.2–7.5 7.32 ± 0.1	62–78 70.4 ± 7.12	––	176–190 186 ± 5.70	45–65 55 ± 7.90	––	––
	WW	7.4–8.3 7.82 ± 0.3	430–445 437.8 ± 5.49	720–780 760 ± 25.49	800–880 843.4 ± 30.86	460–468 464 ± 4.0	46–48 46.6 ± 1.34	61–64 62.4 ± 1.14
R	W	7.1–7.5 7.34 ± 0.1	82–90 86 ± 3.16	––	186–190 188 ± 1.58	53–56 54.6 ± 1.14	––	–––
	WW	7.1–8.5 7.58 ± 0.5	485–501 492 ± 6.44	740–790 775.2 ± 22.0	824–847 836.2 ± 10.54	377–389 383 ± 4.63	42–48 45.8 ± 2.48	56–59 57.4 ± 1.14
S	W	7.1–7.5 7.3 ± 0.15	84–88 85.6 ± 2.19	––	181–188 184.8 ± 2.77	55–60 57.6 ± 2.40	––	––
	WW	6.9–7.2 7.12 ± 0.1	388–411 397 ± 8.71	474–485 478.8 ± 4.86	882–892 888.2 ± 4.49	320–336 329.2 ± 7.56	42–47 44.4 ± 2.30	64–66 65 ± 1.0

Note: I= Industries, W=Water, and WW=Wastewater, A=Alkalinity (mg/l), COD= Chemical Oxygen Demands (mg/l), TDS=Total Dissolved Solids (mg/l), TSS= Total Suspended Solids (mg/l), P=Phosphate (mg/l) and S= Sulphate (mg/l).

Observations and Discussion

Paper entitled "Physico chemical analysis of textile industrial effluents from Tirupur city, TN, India (Manikandan *et al*., 2015)", has conducted study for textile industry and found that pH, phosphate and sulphate parameters for wastewater are within CPCB standard. Similar study entitled "Physico-chemical parameters of wastewater effluents from Taloja industrial area of Mumbai, India", (Lokhande *et al*., 2015) has detected elevated levels of alkalinity in the effluents. Similar results were reported in this study as printing industry S alkalinity exceeds than the standard given by the CPCB in wastewater. A similar study entitled "Water Quality Assessment and Treatment of Pharmaceutical Industry Wastewater: A Case Study of Pharmacity Selaqui, Dehradun of Uttarakhand State, India" (Gupta *et al*., 2018), where detected elevated levels of COD, TDS and TSS in the effluents of a comparable industrial setting.

Similar study has been conducted in preidentified printing industries of India and found that pH, phosphate and sulphate parameters for wastewater of these printing industries are within CPCB standards. Similar findings were reported for industries Q and R that COD, TDS and TSS exceed than the standard given by the CPCB. Also, the values of COD exceed in industry S & R etc. Therefore, it is clear from the observation that, Industries Q and R are not in compliance with CPCB standards in their wastewater discharge. Industry S is also not in compliance with alkalinity in its wastewater discharge. Industries P, Q, and S generally comply with standards for water quality parameters.

The concentration levels of identified pollutants were found to exceed recommended environmental standards in several instances. This indicates a potential threat to aquatic ecosystems and raises concerns about the long-term impact on public health. Pollutants associated with the investigation the physicochemical characteristics of water and wastewater are high levels of dissolved solids, such as salts and minerals, is present in industrial wastewater. It impacts water quality and aquatic ecosystems, affecting both flora and fauna. Excessive discharge of nutrients, such as phosphorus, from industrial activities leads to eutrophication in water bodies, causing algal blooms and disrupting the ecological balance. Printing processes contribute to fluctuations in pH levels in water. Both acidic and alkaline discharges have detrimental effects on aquatic life and the overall stability of the water environment. Solid particles, including fine particles from paper and other materials used in printing, are suspended in wastewater. These solids contribute to turbidity and negatively impact aquatic habitats. Printing industry effluents contain substances that contribute to high COD levels. Elevated levels of these parameters indicate the potential for oxygen depletion in water bodies, negatively affecting aquatic life.

Conclusion

Industries Q and R are not in compliance with CPCB standards in their wastewater discharge. Industry S is also not in compliance with alkalinity in its wastewater discharge. Industries P, Q, and S generally comply with standards for

water quality parameters. Industries in which parameter values exceed CPCB standards need to take corrective measures to meet regulatory requirements.

Investigation into the physicochemical characteristics of water and wastewater in the printing industry provides crucial insights into the environmental impact of printing processes and contributes to the governing body of knowledge on industrial pollution. Identifying pollutants, assessing concentration levels, and understanding physico-chemical parameters collectively form a foundation for informed decision-making and sustainable practices in the printing industry.

Acknowledgment

The authors are thankful to the Department of Environmental Science & Engineering for providing lab and testing facilities. Also, I duly acknowledge the Department of Printing Technology, GJUS&T, and Hisar for providing the required infrastructure and facilities for research work. Special thanks to those who helped directly or indirectly during this experimental research activity.

Funding

This research did not receive any specific grant from public, commercial, or not-for-profit funding agencies.

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