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Decentralized Wastewater Treatment Solution for Commercial and Housing Complex through TADOX® Technology

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High water demand is accompanied by high wastewater discharge. The wastewater when discharged untreated or with inadequate treatment has a cumulative effect in deteriorating the quality of receiving water. In the present article, **Dr Nupur Bahadur** and **Dr Nimisha Singh** discuss TADOX® technology and its potential for suitably treating wastewater. To facilitate understanding, the discussion is supplemented by a case study. The TADOX® technology possesses features that makes it far superior to the existing conventional and costlier wastewater treatment technologies.

Background

Post-pandemic era in which the world is juggling to balance work and home together in a totally different and new way as some companies offer work-from-home options for its employees but some not, the real estate market has observed a constant upswing. The development of real estate includes building and developing residential and commercial entities for government as well as for public in large. In the Indian context, this sector is expected to reach US$ 1 trillion in market size by 2030 and will contribute towards 13% country's GDP by 2025 (Real Estate Industry Project 2022). This sector not only has crucial role in increasing country's GDP but also plays an important part in realizing national missions such as Swachh Bharat Mission—one step towards cleanliness. Such missions were realized by the Government of India in order to address the rapid urbanization which confers increased water demand and subsequent release of mammoth amount of wastewater. The wastewater when discharged untreated or with inadequate treatment has a cumulative effect in deteriorating the quality of receiving water. The 2011 Census reports that only 32.7% of the total urban household is connected to piped sewer system (Singh 2018). Thus, in 2016 Ministry of Urban Development, Government of India issued Model Building Bye-Laws (MBBL) which assert for on-site sewerage treatment and wastewater reuse in large building projects (Model Building Bye-Laws 2016).

In the Indian context, norms framed by regulatory bodies such as Central Pollution Control Board (CPCB) are set in-place. Despite this, the discharge of untreated/ inadequately treated effluents from high-rise housing societies, group housing societies, commercial buildings into nearby open spaces and drains is a common phenomenon. The receiving body in-turn gets severely impacted with poor aesthetics, odour issues, having sewage with high biochemical oxygen demand (BOD) and chemical oxygen demand (COD), which ultimately leads to low dissolved oxygen (DO) levels, indicating very poor water quality, thus poses a severe environmental hazard.

Further, the major infrastructure development industry that lies in special economic zone (SEZ) which are into developing, processing, and non-processing areas such as office spaces, service apartments, residential and commercial complexes, food courts, health centres, etc. are also found to be violating the treatment, safe disposal, and discharge norms. Simply because the conventional effluent treatment plant (ETP)/sewage treatment plant (STP) working on biological treatment phenomenon, is not able to bear the shock load, especially when industries are having different functioning areas (processing and non-processing) and mixed quality of effluent is generated. Also, conventional biological treatment systems have large land requirement, takes on average 12–24 hours in treatment, leading to high demand of resource and energy-intensive process. Ultimately the treated water quality is sufficient only for dilution and horticulture use. For high end applications like the water for cooling tower, fire extinguishing, storage, flushing, etc. there is high dependence on groundwater and other sources such as the tankers from the municipal corporations, etc. Thus, the problem is prevalent for commercial and housing complexes spanning across India and there is requirement of strategic approach to deal and provide such a solution that could also go long way in accomplishing policy tool for the country in similar sectors.

Recent case

On similar ground, a case was recently found near The Energy and Resources Institute (TERI) Gurugram Campus. A problem of water logging was identified within the TERI premises. So, during reconnaissance survey of the area, it was noted that the untreated sewage from the nearby SEZ is being discharged into the storm water drainage which gets accumulated on the low-lying land near the SEZ area (refer Figure 1). Owing to heavy rain and continuous discharge of untreated sewage from the SEZ area the water overflowed from the area where it usually accumulates and flooded the nearby areas (Figure 2: 4a, 4b, 5, and 6). The untreated sewage being discharged in the storm water drains was also getting accumulated inside the TERI Campus (Figure 2: 6a and 6b). The elevation difference from point 1 to point 5 inside TERI Campus is almost 5 metres.

Figure 1: Google Earth Image of survey area showing TERI Campus (yellow), Farmhouses (pink), SEZ (green), water-clogged area (red) and water flow from SEZ towards TERI and farmhouses (Blue)

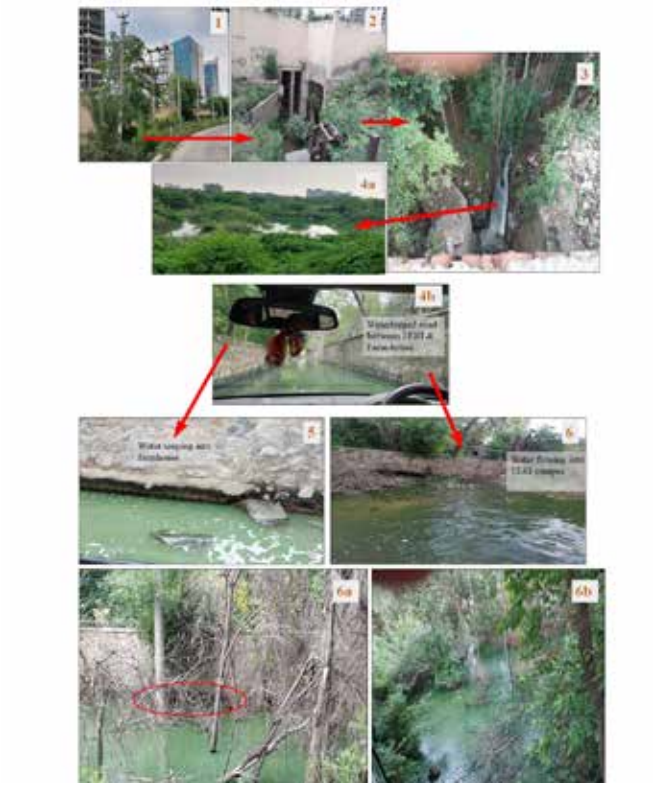


Figure 2: Photographs of overflow and water-logged area
Source: Google Earth Image

Thus, for a point source pollution abatement of such kind a decentralized wastewater treatment technology needs to be explored.

TADOX® technology

TERI's Advanced Oxidation Technology (TADOX®) involves majorly two stages of treatment. The stage 1 process involves novel primary treatment approaches with newer formulations of coagulants and flocculants. The aim of primary treatment is reduction of Toxic Shock Syndrome (TSS) by 90%, such that suspended impurities do not interfere with the UV light, to be imparted at secondary treatment stage. The secondary stage treatment, that is, stage II, involves UV-photocatalysis as an advanced oxidation process (AOP), where TiO_2 nanomaterials

(NMs) are mixed with the effluent, provided contact time and aeration and passed into a photocatalytic reactor (PCR) having suitable UV light radiation source.

TiO_2 NMs being semiconducting in nature get self-activated in the presence of UV light and *in-situ* generates hydroxyl radicals, which acts as oxidizing agents and leads to oxidative degradation and mineralization of targeted pollutants. The UV-TiO_2 photocatalytic action leads to generation of hydroxyl radicals for oxidative degradation of pollutants.

Used nanomaterials are recovered using suitable filtration systems, regenerated and reused for treatment up to a large number of cycles and even months in some cases, showing same efficiency. The treated water is colourless, odourless and adequately treated, and goes as feed to tertiary treatment, which may require RO, followed by use of evaporators, depending upon point of use application.

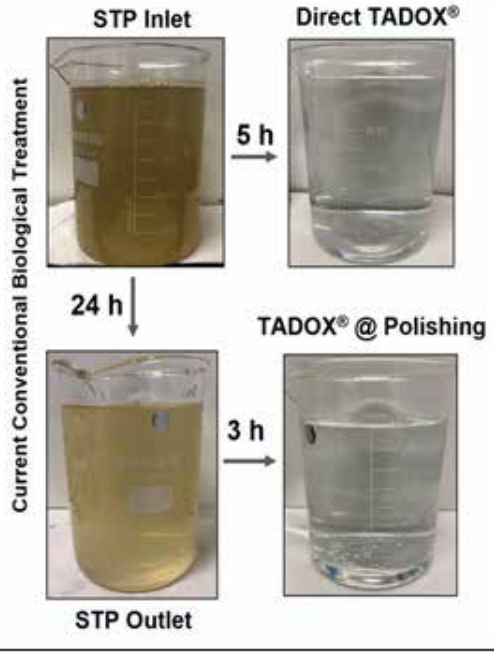
The key features of TADOX® technology that makes it far superior to the existing conventional and costlier wastewater treatment technologies are:

- Operating conditions: works at ambient temperature and pressure
- No secondary pollution: involves complete degradation/ mineralization of pollutants to innocuous carbon dioxide and water or convert them to less harmful/non-toxic compounds
- Target compounds: operative at traces of a wide variety of complex molecules
- Clean and green technology: use of nanomaterials ensures less use of chemicals
- Shorter treatment time: helps in enhancing capacities and augment capacities of existing ETP/STPs
- Modular system: retrofitted in existing treatment systems
- No stream segregation: technology can treat mixed effluents containing sewage
- Energy and resource efficient: mixed sewage can be treated directly without any pre-biological treatment
- Reduced cost of treatment: 25–30% reduction in operational expenditure (OPEX) and capital expenditure (CAPEX)

Having such features, TADOX® technology has been used to generate 25+ case studies for different industrial wastewater in different geographical areas. Some of these work has been discussed here (Bahadur and Bhargava 2022).

STP INLET	
pH	7.9
Colour, (Pt- Co) (CU)	185
COD, mg/L	650
BOD, mg/L	261
TSS, mg/L	380
Total N, mg/L	32.0
Total P, mg/L	81.2
E. coli, MPN/100 ml	1.02×10^5
Total Coliform bacteria, MPN/100 ml	6.12×10^6
Total count, CFU/100 ml	5.24×10^5

STP OUTLET	
pH	8.2
Colour, (Pt- Co) (CU)	125
COD, mg/L	400
BOD, mg/L	78
TSS, mg/L	110
Total N, mg/L	30
Total P, mg/L	13
E. coli, MPN/100 ml	1.21×10^4
Total Coliform bacteria, MPN/100 ml	1.13×10^5
Total count, CFU/100 ml	1.84×10^4



DIRECT END-TO-END TADOX®	
pH	8.0
Colour, (Pt- Co) (CU)	8
COD, mg/L	64
BOD, mg/L	7
TSS, mg/L	<5
Total N, mg/L	1.9
Total P, mg/L	<1
E. coli, MPN/100 ml	16
Total Coliform bacteria, MPN/100 ml	1.16×10^2
Total count, CFU/100 ml	28

TADOX® AT POLISHING STAGE	
pH	8.1
Colour, (Pt- Co) (CU)	5
COD, mg/L	46
BOD, mg/L	<3
TSS, mg/L	<5
Total N, mg/L	1.7
Total P, mg/L	<1
E. coli, MPN/100 ml	<8
Total Coliform bacteria, MPN/100 ml	3.13×10^2
Total count, CFU/100 ml	11

Figure 3: Municipal sewage treatment by TADOX® technology

TADOX® as decentralized wastewater treatment plant for sewage and municipal wastewater

The case study presented here includes the treatment of Delhi Jal Board's municipal wastewater to enhance water reuse. The treatment was done with two approaches: 1. directly treating the raw effluent entering the STP called **Direct TADOX** and 2. polishing of treated wastewater from STP called **TADOX @ polishing**.

The quality of water after TADOX® treatment has improved substantially with BOD and COD reduction of 97% and 90%, respectively as compared to the conventional treatment where reduction for BOD is 70% and COD is 38%. TADOX® as polishing step has reduced BOD to <3 mg/L which meets the discharge norms by CPCB. The improved water quality also meets the reuse norms for high end application. Total time of treatment is reduced to 4–5 hours as compared to average 12–24 hours. There is possibility of complete bypass of any kind of biological treatment leading to much more resource and energy efficient treatment with treated water quality available for high-end reuse.

Key takeaways

The point source pollution is quite big and prevalent across India. So, rather than defaming and imposing penalties on the infrastructure developers, an approach to involve the stakeholders' discussions that includes builder, government regulators and technology developers may address this challenge. The TADOX® technology not only has the potential to address the aforementioned challenges and produce high quality of treated water that meets the National Green Tribunal (NGT) and CPCB surface discharge norms but also is highly suitable for reuse in high end applications such as the water for cooling tower, fire-extinguishing, storage, dust suppression, floor cleaning, toilet flushing, etc. along with horticulture and landscaping.

This approach also has potential to treat wastewater at the source because of minimum land requirement, can be retrofitted with other treatment processes, augment the overall treatment capacity which would ultimately reduce the dependency on freshwater usage for non-potable application in large buildings and complexes. Thus, such a technological innovation has direct societal and environmental impact together serving the missions of national interest like the Swatch Bharat and Smart Cities Mission, etc.

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