Migration Letters

Volume: 21, No: S6 (2024), pp. 989-1000

ISSN: 1741-8984 (Print) ISSN: 1741-8992 (Online)

www.migrationletters.com

Nature-Based Treatment Technologies For Personal Care Product Ingredient Removal

Marri Srinivasa Reddy[1] Dr. S. Gnanakumar[2] Dr. K. ChandraMouli[3]

Abstract

As a consequence of technological advancement and the essential for wastewater treatment systems with low operating costs, we have created environmentally driven treatment methods to mitigate environmental concerns. Conventional technology has shown to be resource intensive, capital-intensive, energy-intensive, highly automated, and labor-intensive. It is also successful in removing pollutants from wastewater. Since then, a more trustworthy and cost-effective method has emerged, one that takes use of organic matter, plants found in their natural environments, and sunlight[37]. This research compared the effectiveness of the standard treatment system with that of a thin Film Diffuse Gradient sampler to look into the frequency of occurrence of organic pollutants.

1.Introduction

EOCs in waste[1]-water effluents may persist, be hazardous, and bioaccumulate in biota. WWTPs purify wastewater before discharging it[43]. Antibiotics, EDCs, pharmaceuticals, and PPCP components may remain in wastewater following conventional treatment[34]. It has also been shown that occasional increases in wastewater influent hydraulic loads seldom surpass the plants' design capacity, resulting in the direct wastewater discharge into recipient water bodies inadequate treatment. Thus, developing innovative wastewater treatment systems to eliminate EOCs is difficult since we must decrease their conservation impact, especially on marine life and nutrition manacles.

ICWs, or integrated built wetlands, may reduce EOCs in wastewater better than WWTPs due to their low operating costs and high storage costs. Plants in wastewater treatment ponds improve water quality at little cost.

This study and others assessed removal efficiency while assessing nature-based technology as a wastewater treatment option. Nature-based methods for reducing nutrient runoff from arable land are cost-effective, but therapies must be affordable. Sedimentation and filtering remove BOD/COD and suspended particles, and Reed beds must be included in the cost[5]. used the Czech Republic's 18 m^2 to 4493 m^2 of vegetated beds and 4 to 1100 people as an example.

Plant absorption, denitrification, and nitrification remove biofilm nitrogen and nitrates, but soil adsorption may lose nitrogen and other nutrients. Calcium, iron, and aluminum precipitations purify phosphorus nutrients. Viruses may die, be filtered, or be adsorbed. Phragmites australis dominates European reed beds. Before releasing nutrients from treatment material, plants must be gathered and decomposed at the right moment.

2.The study's objectives

[1]Department of civil engineering Annamalai University, Chennai, 608002, Indi,
[2]Department of civil engineering Annamalai University, Chennai, 608002, India,
[3]Department of civil engineering NRI Institute of Technology, Guntur, 522438, India,

This research compared the efficiency of three conventional and six natural wastewater treatment facilities in Italy in removing pollutants from items. It aims to determine if environmental based systems are a feasible another to conservative W.W.T.P s by comparing their capabilities and features.

3. Resources and Procedures

3.1 Elements and Substances

All compounds utilized in the production of DGTs at Bio life limited (Hyderabad) are listed in Table Information is provided in Table 1.

Name	**Purity**
Acetonitrile	HPLC
Agarose	Bio-analysis
Ammonia solution	5M, analytical
Ammonium persulfate	≥ 99%, analytical
Gel solution	-
Hydrophilic-Lipophilic-Balanced	-
Milli-Q water	18.2 MΩ cm^{-1}
Methanol	H.P.L.C
Tetramethyl ethylenediamine	99%
Sodium chloride	99%,

3.2 DGT Analysts Research

HLB binding gels were 0.56 mm thick with 0.35 mm spacers, and a 0.80 mm agarose disseminative gel was used on top.

3.3 Sampler

The current investigation opted to examine a collective of nine wastewater treatment plants (WWTPs) located in Vijayawada. This group consisted of three conventional and six environmentally sustainable facilities. Table 2 presents a concise overview of the average temperature, pH levels, and internal treatment methodologies utilized by the selected WWTPs. The present study employed the use of Dispersive Inclines in Tinny Films (D.G.T) passive samplers, a technique that is both cost-effective and simple, to collect waterway samples for the purpose of quantifying treatments and individual care products (PPCPs) in the flowing in waste of wastewater treatment plants. During a 7-10day period in June 2020, a comprehensive evaluation was conducted on 54 Diffusive Gradients in Tinny Films (D.G.T) in triplicate at the inflowing, intermediate, and effluent locations of the Wastewater Treatment Plants (W.W.T.Ps).

3.4 Compounds of Concentration

Preservatives, antioxidants, and endocrine disruptors were the three categories of compounds that underwent testing. (EDCs). The parabens benzylparaben (BEP), butylparaben (BUP), isobutylparaben (i-BUP), propylparaben (PRP), 4-hydroxybenzoic acid (PHBA), ethylparaben (ETP), butylparaben (BUP), isobutylparaben (i-BUP), and triclosan (TCS) are among those that are toxic to human (TBHQ).

3.5 Quality Control

The samples and reference standards were generated concurrently within a singular operation at Bio life limited. (Hyderabad). The Department of Chemistry at Anna University dispatched samplers via air freight(DHL). The samplers were furnished with internal standards and sampling equipment, and laboratory extractions were performed using travel blanks and filing blanks. As part of instrumentation experiments, the machine was subjected to laboratory blanks.

3.6 DGT Extraction

Prior to extraction, the DGT molding surfaces were cleansed of worms and organic residues through the use of Milli Q water. The HLB binding gels of the DGT molds were extracted and transferred to 15-ml vials. The samples were subjected to injections of various parabens, including P.H.B.A-D4, E3-D2, T.C.S-D3, B.P.A-D16, E2-D5, E.E2-D4, and E1-D4. Five milliliters of Fisher Scientific acetonitrile were added to each sample, which was then transferred to a 15-milliliter vial and subjected to ultrasonic treatment for a duration of 30 minutes. In this instance, the extractions were conducted using fresh 5 ml vials subsequent to the separation of the organic solvents into distinct containers, which were subsequently stored at a temperature of 40C in a freezer. A volume of 400 litres of MQ water with a composition of 20/80 was mixed with 100 litres of sample solution. A syringe filter with a diameter of 0.22 mm made of PTFE material was utilised to filter a volume of 500 litres. The filtered samples were subsequently transferred to vials and subjected to further analysis using LC-MS techniques.

3.7 Biochemical study

The Shimadzu Liquid Chromatograph Mass Spectrometer 8040 was used to analyze the constituents of a Personal Care Product. Ten liters of each extract were loaded onto an XBridgeR C18 column with a guard column. The mobile phase was comprised of 5 mM NH4OH in both acetonitrile and Milli-Q water. The gradient process was composed of 15% 5mM NH4OH ACN held for nine minutes, five minutes of 80% HN4HACN held for five, and four minutes of 100% HN 4OH ACN. 7.5 minutes of post-run time was required to get the column back to its original state before the next injection.

The internal standard method was used for the measurement of the analytes, but manual integration was necessary for a few of the compounds. Chen et al. (2017) have used this method before

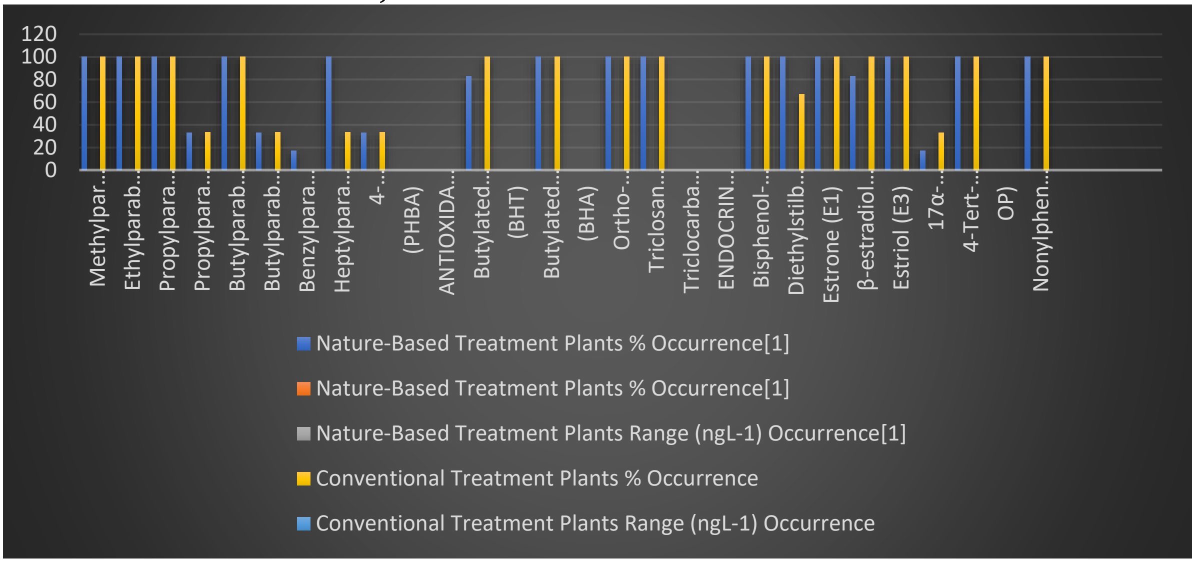
3.8 Quantification

Target analyte concentrations of 1, 2.5, 5, 10, 25, 50, 100, 250, and 500ng/ml were used to generate internal calibration curves with correlation values of 0.999.

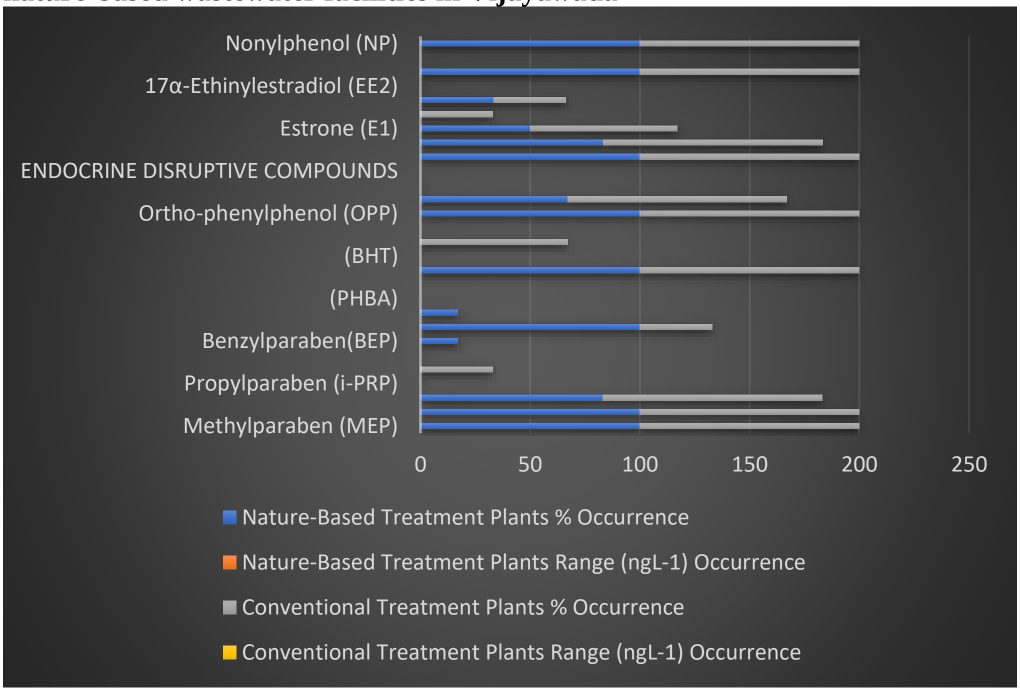
4. Results and Discussion

Data on DGT concentrations for a few analytes in the influents and effluents of traditional and biodegradable wastewater treatment facilities in Italy are shown in Tables 3 and 4. The absorption mass of these chemicals in the binding gel serves as evidence of their frequency.

Graph:1 Concentrations of PPCPs constituents in the Vijayawada wastewater treatment facilities' influences, both conventional and natural



Graph:2 PPCPs component concentrations in the effluents of conventional and nature-based wastewater facilities in Vijayawada



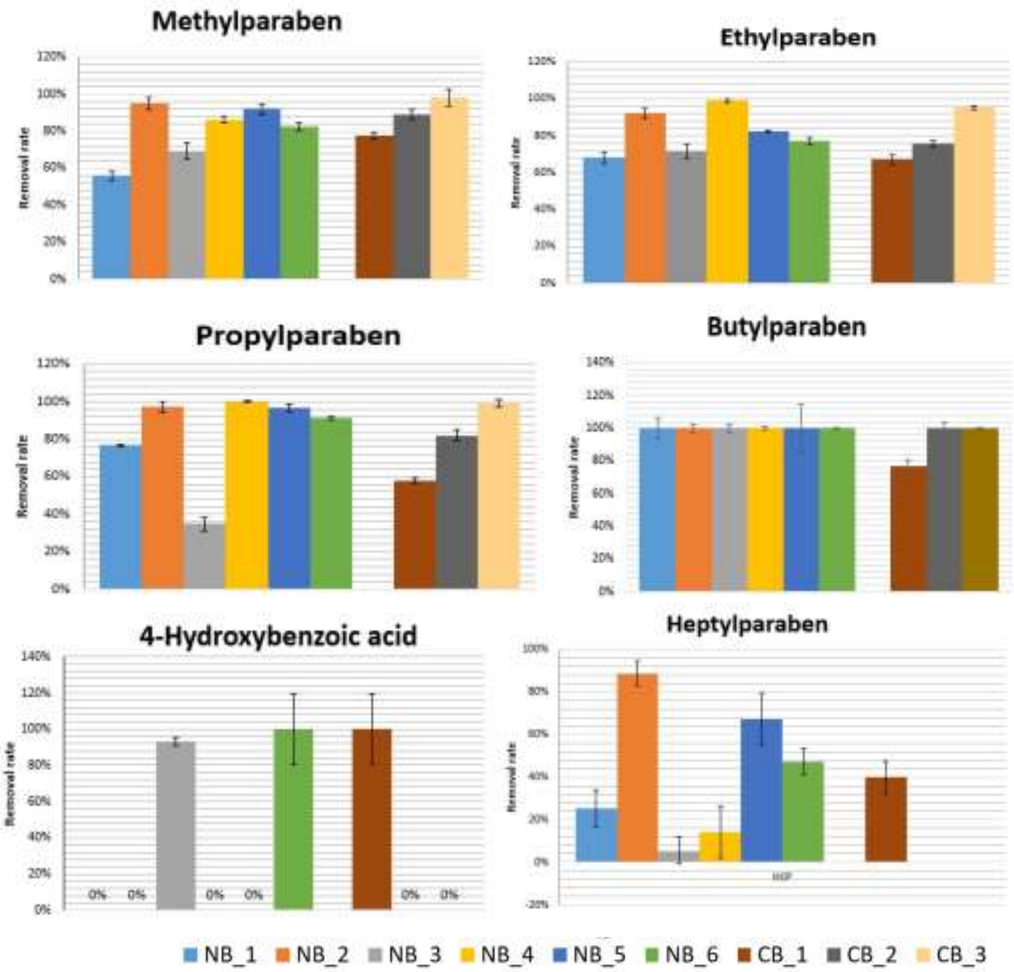
The selected analytes fell into three groups: endocrine disruptors, antioxidants, or preservatives. In the influents of the nature-based and conventional WWTP 2, respectively, tert-butyl hydroquinone (TBHQ) was only discovered at concentrations of 17.4 and 11.1 ngL-1. Both manufacturers' effluents were found to be completely free of TBHQ, suggesting that this chemical is uncommon in the area. Nonylphenol (NP) concentrations were highest in the influents and effluents, with influent levels between 2200 and 4300 ngL-A and effluent values between 4200 and 27000 ngL-F. The high levels of this chemical found in all of the treatment plants examined suggest that none of the two approaches can effectively remove it.

4.1 Nonylphenol

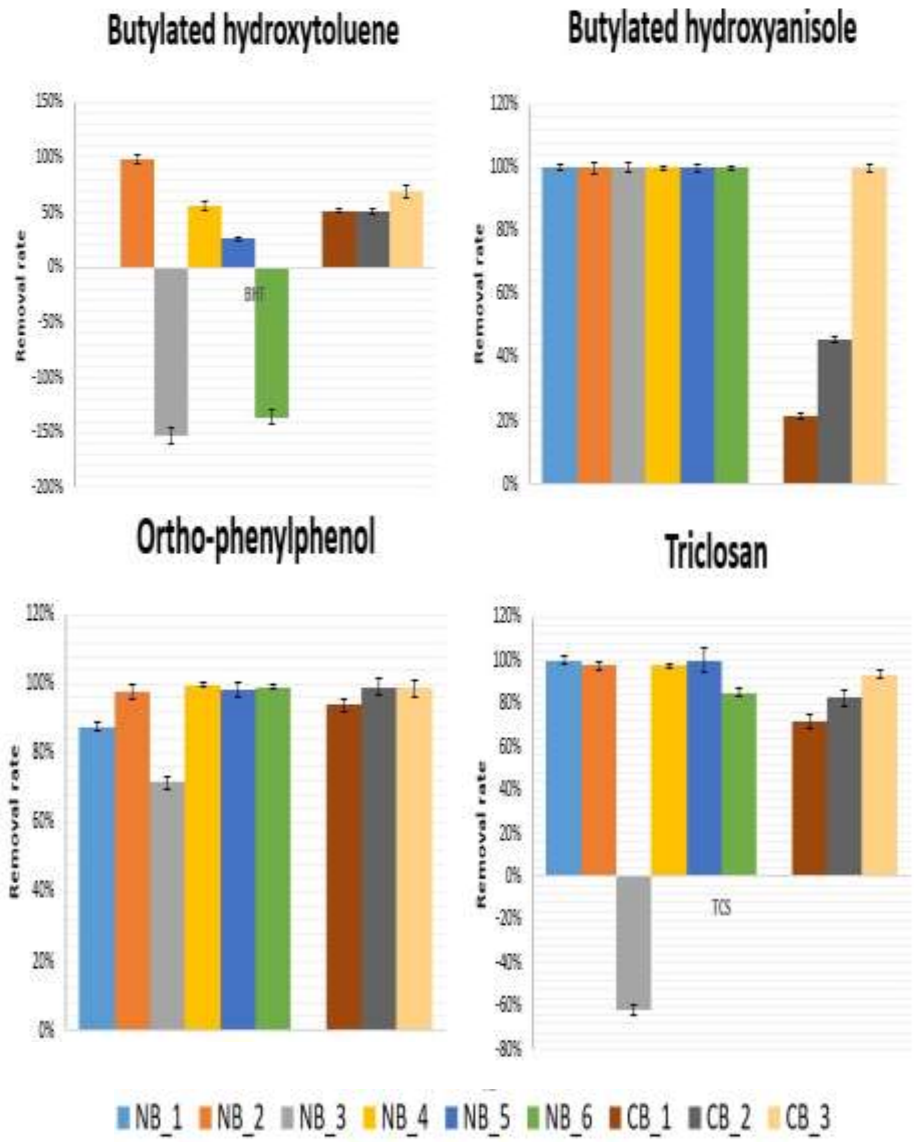
Nonylphenol belongs to the category of chemical compounds known as "long chain alkyl phenols" (LCAPs). Solubilizers, emulsifiers, laundry and dishwashing detergents, and antioxidants are common uses for them, but endocrine disruptors and xenoestrogens have captured the attention of environmental scientists due to their potential active roles in the environment. It is a common constituent of water and soil samples, as well as effluents from wastewater treatment facilities and sludge, and commercial formulations for textiles and clothing often include a class of surfactants called NPEs. This explains why greater concentrations were found in the effluent channels. Tables 3 and 4 detail the tested substances' individual concentrations.

4.2 Exclusion tolls

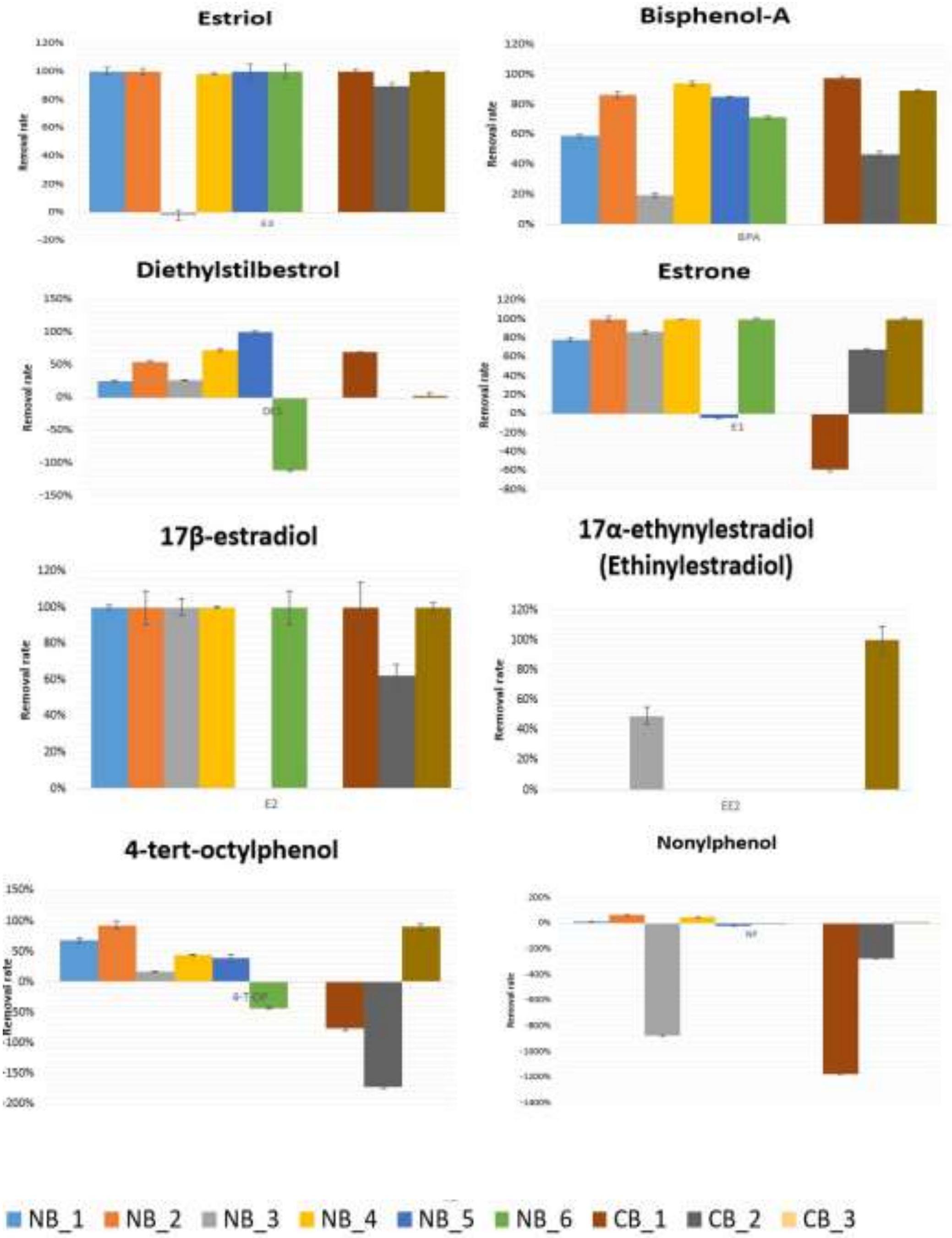
Six different WWTP technologies were analyzed to determine the rates at which study compounds were removed from the body. Research showed that both natural and conventional treatment approaches were equally effective in removing preservatives. The clearance rate r40% H.E.P to 100% B.U.P for conventional treatment system, while it was 5-5% HEP for each of the nature-based methods.



Graph 3: Preservative removal rates in natural and conventional wastewater treatment.
Conventional methods and two natural technologies successfully eliminated all traces of isobutylparaben and isopropyl paraben, while Tert-butylhydroquinone was eliminated with 100% efficiency by both conventional and nature-based methods.

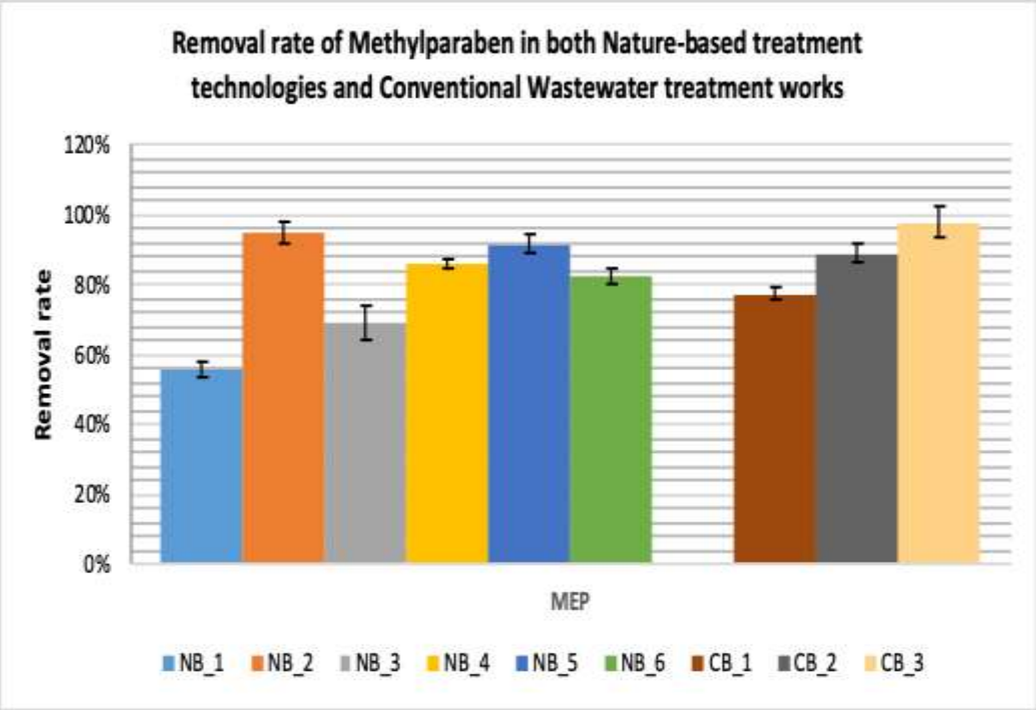


Graph 4: Antioxidants are removed in both NB and CB treatment technologies.
Both treatments removed antioxidants. Traditional treatment works removed 22% to 100% BHA, while NB technologies removed less than 1% to 100%.

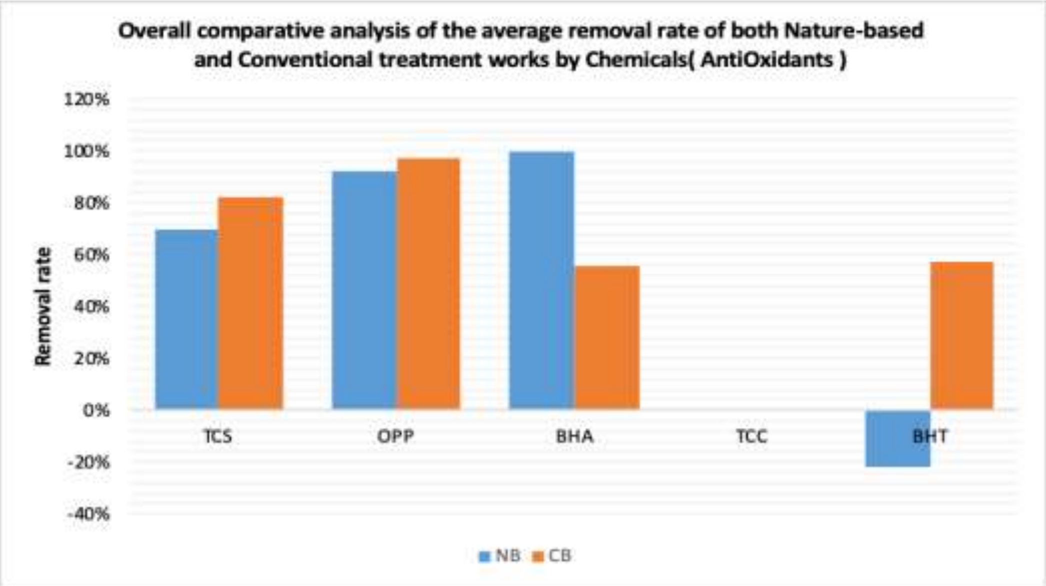


Graph 5: Endocrine disruptors are removed by both natural and conventional wastewater treatment methods.

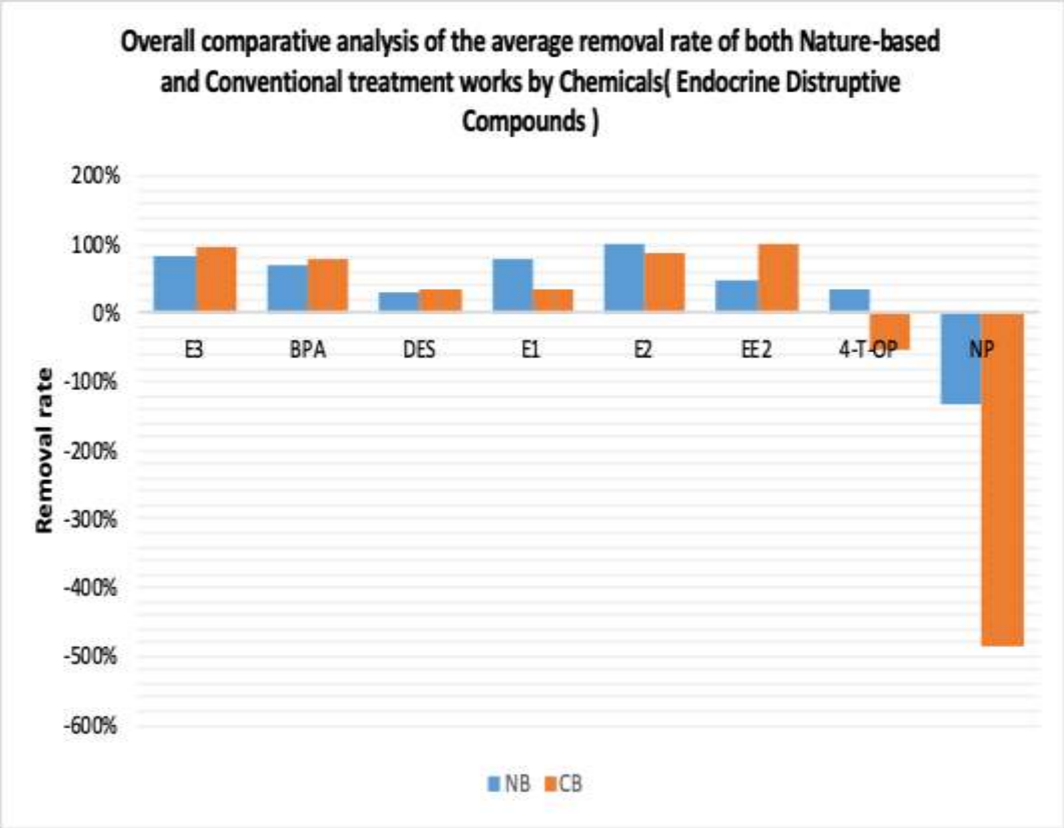
Conventional treatment works had the highest EDC elimination rates, up to 100% EE2, while natural based treatments had the lowest, ranging from NP to 100% E2. Preservatives, antioxidants, and endocrine-distributive compounds accounted for the remaining data. Figure 4a compares the methylparaben removal efficiency of several WWTPs.



Graph 6a: For the elimination of preservatives, natural treatments may be compared to traditional wastewater treatment facilities.



Graph6b: Antioxidants in wastewater may be removed using both traditional wastewater treatment techniques and treatments based on nature.



Graph6c: **Endocrine disrupting substances may be eliminated using both conventional wastewater treatment and natural therapies.**

Graph 6(a)–(c) show the typical exclusion charges for nature-based and conventional systems, showing that both are chemically reliant. M.E.P, B.U.P, E.T.P, P.R.P, T.C.S, and B.U.P show a small negative correlation of -0.38 between the log Koc and the Environmental-based system and a very feeble optimistic correlation of 0.08 thru the standard treatment system. Nature-based solutions outperformed wastewater treatment approaches for nonylphenol.

5. Conclusion

This analysis compared the ability of conventional and green wastewater treatment systems to remove pharmaceutical and individual maintenance product components (PPCPs) from wastewater. The results showed that chemical efficacies were more important than technological ones in the removal process. Factors such as initial investment, population, wastewater type, and preexisting chemical use all play a role in determining the most suitable technique. Plants and microorganisms simplify the exclusion and reprocessing of nutrients and metallic element in water and sediments, but these practices promote eutrophication. Most POPs are effectively removed by both systems, with the exception of antioxidants and Triclosan.

The efficiency of both waste water treatment procedures is affected by a number of crucial criteria, including what they're treated effluents look like chemically. More investigation into the existence of the maternal forms of those complexes with harmful eliminations at inflowing channels is needed to show the success of removal of such compounds and assess both technologies correctly.

Notes and Reference:

1. A.Soaresa et al. (2008) 'Nonylphenol in the environment: A critical review on occurrence, fate, toxicity and treatment in wastewaters', Environment International. Pergamon, 34(7), pp. 1033– 1049. doi: 10.1016/J.ENVINT.2008.01.004.
2. Anderson, F. A. (2008) 'Final report on the safety assessment of isobutylparaben and isopropylparaben', International Journal of Toxicology, pp. 1–82. doi: 10.1080/10915810802548359.
3. Begg, J. S., Lavigne, R. L. and Veneman, P. L. M. (2001) 'Reed beds: Constructed wetlands for municipal wastewater treatment plant sludge dewatering', in Water Science and Technology, pp. 393–398.
4. Boberg, J. et al. (2018) 'Multiple Endocrine Disrupting Effects in Rats Perinatally Exposed to Butylparaben', 152(July), pp. 244–256. doi: 10.1093/toxsci/kfw079.
5. Brix, H. (1994) 'Use of Constructed Wetlands in Water Pollution Control: Historical Development, Persent Status, and Future Perspectives', Water Science and Technology, pp. 209–223.
6. Brix, H. (1997) 'Do macrophytes play a role in constructed wetlands?', Water Science and Technology, pp. 11–17. doi: 10.1016/S0273-1223(97)00047-4.
7. Bu, Q. et al. (2013) 'Pharmaceuticals and personal care products in the aquatic environment in China: A review', Journal of Hazardous Materials. doi: 10.1016/j.jhazmat.2013.08.040.
8. Carbajo, J. B. et al. (2014) 'Personal care product preservatives: Risk assessment and mixture toxicities with an industrial wastewater', Water Research, 72, pp. 174–185. doi:
    a. 10.1016/j.watres.2014.12.040.
9. Chen, C.-E., Zhang, H. and Jones, K. C. (2012) 'A novel passive water sampler for in situ sampling of antibiotics', Journal of Environmental Monitoring, 14(6), p. 1523. doi: 10.1039/c2em30091e.
10. Chen, C. (2013) 'Development and Applications of a Novel Passive Water Sampler for Polar Organic Contaminants-Antibiotics', (December).
11. Chen, M. et al. (2006) 'Pharmaceuticals and endocrine disruptors in wastewater treatment effluents and in the water supply system of Calgary, Alberta, Canada', Water Quality Research Journal of Canada, 41(4), pp. 351–364.
12. Chen, T. Y. et al. (2006) 'Application of a constructed wetland for industrial wastewater treatment: A pilot-scale study', Chemosphere, 64(3), pp. 497–502. doi:
    a. 10.1016/j.chemosphere.2005.11.069.
13. Chen, W. et al. (2017) 'DGT Passive Sampling for Quantitative in Situ Measurements of Compounds from Household and Personal Care Products in Waters', Environmental Science & Technology, 51(22), pp. 13274–13281. doi: 10.1021/acs.est.7b03940.
14. Commission Regulation (EU) No 1004/2014 (2014) 'Commission Regulation (EU) No 1004/2014 of 18 September 2014 amending Annex V to Regulation (EC) No 1223/2009 of the European Parliament and of the Council on cosmetic products', Official Journal of the European Union, L 282(1004), pp. 10–13.
15. Contrera, R. C. et al. (2015) 'The "chemical oxygen demand / total volatile acids" ratio as an anaerobic treatability indicator for landfill leachates', Brazilian Journal of Chemical Engineering, 32(1), pp. 73–86. doi: 10.1590/0104-6632.20150321s00003024.
16. Cowan-Ellsberry, C. E. and Robison, S. H. (2009) 'Refining Aggregate Exposure: Example using
    a. Parabens', Regulatory Toxicology and Pharmacology, 55(3), pp. 321–329. doi: 10.1016/j.yrtph.2009.08.004.
17. Crinnion, W. J. (2010) 'Toxic effects of the easily avoidable phthalates and parabens', Alternative Medicine Review.
18. Darbre, P. D. and Harvey, P. W. (2014) 'Parabens can enable hallmarks and characteristics of cancer in human breast epithelial cells: A review of the literature with reference to new exposure data and regulatory status', Journal of Applied Toxicology. doi: 10.1002/jat.3027.
19. Decamp, O. and Warren, A. (1998) 'Bacterivory in ciliates isolated from constructed wetlands (reed beds) used for wastewater treatment', Water Research, 32(7), pp. 1989–1996. doi: 10.1016/S0043-1354(97)00461-2.

20. Dunne, E. J. et al. (2012) 'Efficacy of a large-scale constructed wetland to remove phosphorus and suspended solids from Lake Apopka, Florida', Ecological Engineering, 42, pp. 90–100. doi: 10.1016/j.ecoleng.2012.01.019.
21. Farooqi, I. H., Basheer, F. and Chaudhari, R. J. (2008) 'Constructed Wetland System (CWS) for Wastewater Treatment', Proceedings of Taal 2007: The World Lake Conference, pp. 1004– 1009.
22. Foster, G. D. and Shala, L. (2006) Inputs and Fluvial Transport of Pharmaceutical Chemicals in An Urban Watershed, Proceedings of the 2006 American Geophysical Union Joint Assembly.
23. Gao, J. et al. (2016) 'Fate and removal of typical pharmaceutical and personal care products in a wastewater treatment plant from Beijing: a mass balance study', Frontiers of Environmental Science and Engineering. doi: 10.1007/s11783-016-0837-y.
24. Gómez-Canela, C. et al. (2014) 'Occurrence of cytostatic compounds in hospital effluents and wastewaters, determined by liquid chromatography coupled to high-resolution mass spectrometry', Analytical and Bioanalytical Chemistry, 406(16), pp. 3801–3814. doi: 10.1007/s00216-014-7805-9.
25. Havranek, I. et al. (2016) 'Degradation and uptake of 4-nonylphenol in plants and earthworms from spiked mineral soil', in International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM.
26. Hirao, I. (1976) 'Use of Carbon Dioxide in Industrial Organic Chemistry —The Behavior of Carbon Dioxide in the Kolbe-Schmitt Reaction—', Journal of Synthetic Organic Chemistry, Japan, 34(5). doi: 10.5059/yukigoseikyokaishi.34.326.
27. Ho, H. and Watanabe, T. (2017) 'Distribution and removal of nonylphenol ethoxylates and nonylphenol from textile wastewater-A comparison of a cotton and a synthetic fiber factory in Vietnam', Water (Switzerland). doi: 10.3390/w9060386.
28. Jia, H. and Yuan, Q. (2016) 'Removal of nitrogen from wastewater using microalgae and microalgae bacteria consortia', Cogent Environmental Science. doi: 10.1080/23311843.2016.1275089.
29. Julis, J. et al. (2014) 'Selective ethenolysis and oestrogenicity of compounds from cashew nut shell liquid', Green Chemistry. doi: 10.1039/c4gc00111g.
30. Kasprzyk-Hordern, B., Dinsdale, R. M. and Guwy, A. J. (2009) 'The removal of pharmaceuticals, personal care products, endocrine disruptors and illicit drugs during wastewater treatment and its impact on the quality of receiving waters', Water Research, 43(2), pp. 363–380. doi: 10.1016/j.watres.2008.10.047.
31. Liu, Y. and Abreu, P. J. M. (2006) 'Long chain alkyl and alkenyl phenols from the roots of Ozoroa insignis', Journal of the Brazilian Chemical Society. doi: 10.1590/S010350532006000300015.
32. Liu, Y. H. et al. (2017) 'Occurrence, distribution and risk assessment of suspected endocrinedisrupting chemicals in surface water and suspended particulate matter of Yangtze River (Nanjing section)', Ecotoxicology and Environmental Safety. doi: 10.1016/j.ecoenv.2016.09.035.
33. Lundin, M., Bengtsson, M. and Molander, S. (2000) 'Life cycle assessment of wastewater systems: Influence of system boundaries and scale on calculated environmental loads', Environmental Science and Technology, 34(1), pp. 180–186. doi: 10.1021/es990003f.
34. Miao, X. S. et al. (2004) 'Occurrence of antimicrobials in the final effluents of wastewater treatment plants in Canada', Environmental Science and Technology, 38(13), pp. 3533–3541. doi: 10.1021/es030653q.
35. Ntengwe, F. W. (2005) 'The cost benefit and efficiency of waste water treatment using domestic ponds - The ultimate solution in Southern Africa', Physics and Chemistry of the Earth, 30(11-16 SPEC. ISS.), pp. 735–743. doi: 10.1016/j.pce.2005.08.015.
36. Oehmen, A. et al. (2007) 'Advances in enhanced biological phosphorus removal: From micro to macro scale', Water Research. doi: 10.1016/j.watres.2007.02.030.
37. Oller, I., Malato, S. and Sánchez-Pérez, J. A. (2011) 'Combination of Advanced Oxidation Processes and biological treatments for wastewater decontamination-A review', Science of the Total Environment. doi: 10.1016/j.scitotenv.2010.08.061.
38. Pozzo, a D. and Pastori, N. (1996) 'Percutaneous absorption of parabens from cosmetic formulations.', International journal of cosmetic science, 18, pp. 57–66. doi: 10.1111/j.14672494.1996.tb00135.x.

39. Priac, A. et al. (2017) ‘Alkylphenol and alkylphenol polyethoxylates in water and wastewater: A review of options for their elimination’, Arabian Journal of Chemistry. doi: 10.1016/j.arabjc.2014.05.011.
40. Rice, C. P. et al. (2003) ‘Alkylphenol and alkylphenol-ethoxylates in carp, water, and sediment from the Cuyahoga River, Ohio’, Environmental Science and Technology. doi: 10.1021/es034105o.
41. Strand, J. A. and Weisner, S. E. B. (2013) ‘Effects of wetland construction on nitrogen transport and species richness in the agricultural landscape-Experiences from Sweden’, Ecological Engineering, 56, pp. 14–25. doi: 10.1016/j.ecoleng.2012.12.087.
42. Struck, S. D., Selvakumar, A. and Borst, M. (2008) ‘Prediction of Effluent Quality from Retention Ponds and Constructed Wetlands for Managing Bacterial Stressors in Storm-Water Runoff’, Journal of Irrigation and Drainage Engineering, 134(5), pp. 567–578. doi: 10.1061/(ASCE)0733-9437(2008)134:5(567).
43. Subedi, B. et al. (2014) ‘A pilot study on the assessment of trace organic contaminants including pharmaceuticals and personal care products from on-site wastewater treatment systems along Skaneateles Lake in New York State, USA’, Water Research. Elsevier Ltd, 72, pp. 28–39. doi: 10.1016/j.watres.2014.10.049.
44. Sundaravadivel, M. and Vigneswaran, S. (2001) ‘Constructed wetlands for wastewater treatment’, Critical Reviews in Environmental Science and Technology. doi: 10.1080/20016491089253.