World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(REVIEW ARTICLE)

Emerging Pollutants- A review of current understanding and future scenario

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World Journal of Advanced Research and Reviews, 2022, 16(02), 074–088

Publication history: Received on 25 September 2022; revised on 31 Octoberr 2022; accepted on 03 November 2022

Article DOI: https://doi.org/10.30574/wjarr.2022.16.2.1119

Abstract

A recently identified community of chemicals found in aquatic ecosystems are pollutants of increasing concern or, literally, emerging pollutants (EPs). It was only the advances in analytical techniques that enabled the identification of these pollutants even at low concentrations. The persistent discovery of new chemicals prompts concerns about their origin routes, their destiny, their transport, their transition and their effect on the aquatic ecosystem. As new chemical substances are continually being generated and scientific research optimizes its awareness of existing and previous pollutants, pollutants of increasing concerns will stay a moving target. EPs primarily originating from the disposal of urban and industrial wastewater effluents, are widespread in the aquatic ecosystems. Owing to the potential biological effect on organisms within the ecosystem, their existence is of worry. A holistic approach to sampling is needed in order to understand their fate and transformations in wastewater and ecosystem. This implies the attainment of relevant evidence and promotes a deeper interpretation of spatiotemporal pollutant patterns and occurrence. During treating of wastewater, owing to more planning criteria and absence of good analytical techniques, there is a shortage of residual pollutants study. This leads to under-reported analysis of many EPs joining wastewater treatment works and the aquatic ecosystem. Sludge can hold concentrations of certain chemicals, during the treatment of wastewater that ends up being applied to agriculture without analysis for EPs. Hence a framework for environmental reporting that is more holistic is needed, so that the destiny and effect of EPs are explored in all environmental systems. This review discusses current understanding of EPs and provides recommendations for better future analysis.

Keywords: Emerging Pollutants; Wastewater; Pharmaceuticals; Personal care Products

1. Introduction

Industries, farming, and the general public use water each day and release several chemicals into waste water. In the problem of contaminating waste water, farming activities, industry releases and humans play an important role. Both of these activities have created different toxins and changed the water cycle, creating a global issues pertaining to their possible effects on wild life and human health.

Present practice and expertise indicate that expenditures will continue to increase in chemical contaminant identification, and reduction. However, with the enormous amount of chemical toxins attributable to the cumulative impact of both, natural mechanisms and anthropogenic impacts tend to account for just a limited fraction of the overall chemical emissions in the spectrum of currently controlled chemical contaminants (Deblonde et al., 2011). The lengthy list of contaminants is further increased by the progressive discovery and introduction of potential emerging pollutants. It is then unlikely that the number of other chemicals that exist on the basis of the presumption that the chemicals

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deemed by regulations are by far the most relevant and that they have the highest risk to the atmosphere, public health and the economy will be neglected by regional and international lists of approved chemicals (Bell et al., 2011). Comparatively recently found classes of unregulated pollutants which exist in aquatic ecosystems, such as pharmaceuticals and care products, are pollutants of increasing concerns or emerging pollutants (EPs) and typically entail chemicals used in daily life and numerous manufacturing ingredients (Barceló, 2003). A wide variety of inorganic and organic pollutants are regulated in surface waters by the regulations listed by the European Commission. (Dulio et al., 2018) (EU Parliament, 2008). Associated with agriculture and industrial chemicals have generally been these. Nevertheless, regulation is anticipated to widen to encapsulate the latest project of medicines 17b-estradiol (E2), 17a-ethinylestradiol (EE2) and diclofenac as a priority harmful chemical, the higher number of municipal derived chemicals described as EPs (Ashton et al., 2004). EPs are not usually chemicals that are recently created. It may be mentioned that three basic groups apply to the word. Substances newly incorporated into the environment are included in the first grouping (e.g., industrial additives). The next group consists of compounds that may have been present in the atmosphere for several years ago, but their existence has been observed only in recent years and their importance has begun to draw attention (e.g., pharmaceuticals) (Geissen et al., 2015). The last group contains chemicals that have been recognized for a longer period of time, and only recently have their possible harmful effects on human health and the ecosystem been understood (e.g., hormones) (Wells et al., 2010). The key concern with EPs is that the existing data for each of these pollutants is sparse and comparatively small, and the relevant detection techniques and instrumentation either aren't yet available or are at an introductory stage (Gavrilescu et al., 2015). That's why the identification of these micro-pollutants in the environment has only become feasible with steady improvement in analytical analysis and evaluation methods. In other words, it is still not clear for several ECs, the potential risk they pose for the environment and public health has been explained, while monitoring strategies and appropriate technologies for further contamination mitigation are still being developed. It is most important to take into account the role of these pollutants in the environment, because they do not occur separately, but as a complex combination, which may contribute to undesirable synergistic impacts. The prevalence in the environment of a large range of potentially harmful EPs permeates a need to recognize their existence, fate and environmental impacts.

This reviews explains current information on the occurrence of EPs in wastewater and surface water. Areas of concern said to be underexplored are addressed from the data collection and broader studies. This include: spatiotemporal heterogeneity of EPs in wastewater and river water, separation of EPs into solid matter during the treating of wastewater, destiny of EPs in aquatic environments and toxicological effects of EPs.

2. Present Understanding of EPs occurrence

Table 1 Important classes of emerging pollutants. (Petrie et al., 2015)

Emerging Pollutant Groups	Examples
Pharmaceuticals	
Antibiotics	Trimethoprim, erythromycin, amoxicillin, lincomycin, sulfamethaxozole, chloramphenicol
Analgesics	Ibuprofene, diclofenac, paracetamol, codein, acetaminophen, acetylsalicilyc acid, fenoprofen
Psychiatric drugs	Diazepam, carbamazepine, primidone, salbutamol
Beta-Blockers	Metoprolol, propanolol, timolol, atenolol, sotalol
Antiepileptic	Carbamazepine, Gabapentin
Steroid Estrogen	Estrone, 17b-estradiol
H2 Receptor Agonist	Ranitidine, Cimetidine
Anti-depressants	Venlafaxine, Dosulepin, Amitriptyline, Nortriptyline
Metabolite	Nortramadol, Norcodiene, Normorphine, Norbuprenorphine, Norfentanyl, Norpropoxyphene, Nordiazepam, 7-Aminonitrazepam, Norketamine, Benzoylecgonine, Norcocaine, Cocaethylene, 6-acetylmorphine
Personal Care Products (PCPs)	
Antibacterial	Triclosan

Plasticizer	Bis-phenol A
Preservative	Methylparaben, Ethylparaben, Propylparaben, Butylparaben
Fragrances	Nitro, polycyclic and macrocyclic musks, phthalates
Sun-screen agents	1-benzophenone, 2-benzophenone, 3–benzophenone, 4-benzophenone, methylbenzylidene camphor
Endocrine Disruptors	Octylphenols, nonylphenols
Surfactants	Alkylphenol ethoxylates, 4-nonylphnol, 4-octylphenol,
Fire Retarders	Polybrominated diphenyl ethers (PBDEs), Tris (2-chloroethyl)phosphate, Hexabromocyclododecanes (HBCDs)
Industrial Additives	Aromatic sulfonates
Gasoline additives	Dialkyline ethers

The existence of EPs in the ecosystem is primarily due to the emission from treatment facilities of waste water. The most widely used and researched methods are traditional secondary processes (activated sludge and trickling filters) and are thus reflected in this study. Such procedures, however are not meant to extract EPs prior to their release into water bodies, like rivers, reservoirs and coastal areas. EPs involve a wide range of natural and synthetic substances that are considered potential threats, but adequate information still isn't known for all the different EPs .Important classes of emerging pollutants are shown in Table 1. Substances like medicines, personal care products (PCPs), endocrine disrupting chemicals (EDCs), steroids, hormones, inhibitors of solvents and surfactants, fire retardants, toxins, synthetic substitutes, nanoparticles, and fuel additives are contained in EPs (Gogoi et al., 2018).

Some of these pollutants occur and remain to a larger degree in the environment, not just in urban countries, but in rural communities as well. Examples of most common pollutants and their key characteristics are listed in Table 2. In the ecosystem, certain contaminants are restrictive and do not decay (e.g., heavy metals). Prolonged organic contaminants (e.g., DDT, EDTA, per fluorinated compounds) are compostable, yet so often medicines are compostable at a very slow pace (e.g., carbamazepine, sulfamethoxazole). Polar water soluble chemicals that are persistent can quickly penetrate into water. This should be remembered that while certain toxins are not permanent in the environment and thus can be changed by natural phenomena, their continual penetration from different sources (e.g. discharges of wastewater treatment plants) enhances and retains their existence in waterways and the potential adverse effects on aquatic life.

Table 2 Common examples of emerging pollutants with their characteristics. (Stefanakis and Becker, 2015)

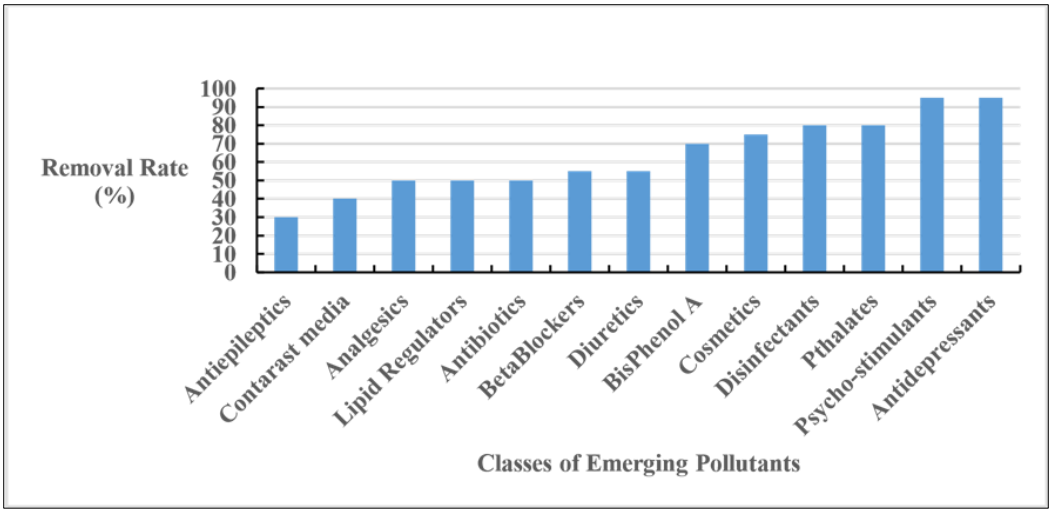
Pollutant	**Origin**	**Persistence**	**Distribution**
Nonylphenol	Non-ionic surfactants degradation	Intermediately persistent	Sludge, wastewater, sediments
Bis-phenol A	Resins, epoxy	No bioaccumulation	Water from surface and ground
Animal medicines	Aquacultures, pastures	Persistent	Soil, sediment, water
Phthalates	Non-biodegradable plastics	Medium persistent	Soil, sludge
Nanoparticles	Pesticides, nanomedicines, landfill leachates	Persistent	Soil, sludge ,rivers
Choloro alkanes, Polybrominated diphenyl ethers	Flame retardants	Persistent, highly bioaccumulative	Groundwater, soil, sludge
Steroids	Contraceptives	Moderately Persistent	Water, sludge, sediment
Sulphanoamides, Tetracyclines	Veterinary and human drugs	Slightly Persistent	Soil, sludge, groundwater

3. Removal Methodologies for Emerging Pollutants

Advanced oxidation processes (AOPs) have been used for the degradation of persistent emerging pollutants in water and wastewater. The process either mineralizes the pollutants or may convert them into less harmful products. This approach has been more often used as a pretreatment unit for other biological treatment such as activated sludge. During treatment by AOPs or ozonation, EPs such as pharmaceuticals and pesticides undergo some spontaneous changes and series of oxidation reactions that can result in formation of degraded products less harmful than parent compounds. The degradation products can be characterized by means of their chemical stability and structure, biodegradability and toxicity. However such studies have been found limited for degradation of halogenated organics. UV assisted AOPs such as photo-Fenton based process has been utilized as an effective degradation process for these compounds. Table 3 below lists the AOPs studied for removal of EPs (Ikehata et al., 2006).

Table 3 AOPS studied for degradation of Pesticides

Process	Oxidants used	Chemicals	Energy sources	Remarks
Fenton	Hydrogen peroxide	Ferrous ion	None	Formation of Sludge
Photo -Fenton	Hydrogen peroxide	Ferric ion	Ultraviolet (UV) radiation or visible light	
Anodic Fenton	Hydrogen Peroxide	Iron Electrode	Electric current	Fenton based reactions occur in Anodic half cell
Photoelectro Fenton	Hydrogen peroxide	Iron electrode	UV or solar radiation	
Ozonation	Ozone	Hydroxyl Ion	None	pH >8
Ozonation/ H2O2/ UV	Ozone, H2O2	None	UV radiation	
Heterogeneous Photocatalysis	None	Titanium dioxide	UV or solar radiation	



Removal Rate of Emerging Pollutants

Figure 1 Removal Rate in Percentage for each class of compounds calculated from average concentration between effluent and influent (Deblonde et al., 2011)

Activated carbon adsorption would be an efficient strategy among the various methods to minimize micro pollutant disposal into the aquatic ecosystem, and a large-scale project has been conducted at the Seine Centre (240,000 m3/d-Paris, France) wastewater treatment facility. Although most of the available works explored fixed bed or contact reactors with a different separation stage, this study examined new types of tertiary treatment based on a fluidized bed containing a high amount of activated carbon, renewed continually. The objectives of the study were to assess the efficiency of the working fluidized bed operating with micro grain activated carbon (μCAG) on both emerging micropollutants and other quality parameters of wastewater and then to correlate its performance and applicability to Powdered activated carbon. In the μGAC configuration, conventional criteria of waste water quality parameters, pharmaceuticals and hormones and other emerging contaminants were observed. With μGAC, pharmaceuticals and hormones are well removed (50 to N90 %). It also achieves removals of 50 to N90 % for Alkyl phenols, bisphenol A, parabens, sweeteners and pesticides. UV absorption at 254 nm, organic dissolved carbon and removal of micropollutants are well correlated. With μGAC, elimination of NH4, NO2 and total suspended solids occurs. The performances obtained with μGAC are comparable to those with activated carbon powder (Mailler et al., 2016).

From the average concentration between all the effluent and the influent, the removal percentage were determined as shown in Fig-1. Nevertheless, negative results have been obtained for some compounds when measuring the removal effectiveness. The negative results may be explained by the lack of data for molecules with small quantities such as Fenofibric acid, Indomethacin, and Iotalamic acid (contrast media). All these studies included primary, secondary and tertiary treatment. The contaminants that are most effectively removed in a treatment plant with an active sludge process are phthalates, which have a removal efficiency of over 90%, and psychostimulants, which have a removal efficiency of about 97% (Bendz et al., 2005). Bisphenol A is removed with about70% of effectiveness (Gómez et al., 2007). Therapeutic molecules such as analgesics, antiinflammatories, and beta-blockers are the least removed (30–40%). This finding is consistent with the recent data collected, during a report commissioned in France in 2009-2010. In treatment facilities, prescription products found in wastewater may be biologically degraded and finish up in water bodies or captured by sludge. Sludge can be used in farmland as fertilisers, and these substances can pass through the soil and enter groundwater. Lowremoval-rate molecules are likely to be contained in various environmental media and can have an impact on ecosystems.

Grape stalk has been used to evaluate its effectiveness as a sorbent for the removal of a fluoroquinolone antibiotic and an azo dye. Both compounds behaved in a pseudo first order kinetic mechanism. Absorption mechanism was held responsible for the removal of these compounds by grape stalk action. The study suggests use of a suitable biomass material used for the preliminary treatment with an objective to reduce the concentrations of toxic substances to be discharged. The grape stalk properties such as lower contact time for adsorption, capacity of sorption, no preliminary treatment requirement and burning under optimum conditions make it a suitable biomass material to be used for the effective removal of some ECs (Nurchi et al., 2019).

Table 4 Removal Efficiency of some EPs in Constructed Wetlands

Emerging Pollutant	Removal Efficiency Range (%)
Ibuprofen	45-80
Ketoprofen	47-90
Naproxen	27-92
Carbamazepine	16-87
Galaxolide	67-90
Diclofenac	17-96
Tramadol	12-85
Paracetamol	90-100
Triclosan	62-93

Due to low energy, operating and maintenance costs and high treatment quality, constructed wetlands (CWs) can be a promising option as tertiary, but also as primary and secondary treatment systems (for organic and nutrient removal). While research into the removal of EPs (particularly pharmaceuticals and personal care products) in constructed wetlands has increased in recent years, the substantial results of work have been performed on a small scale (laboratory,

pilot), as well as little data on the large-scale use of constructed wetlands is available. Table 6 presents some removal efficiencies of Eps by different configurations of constructed wetlands (Vasilachi et al., 2021).

Anaerobic membrane bioreactors (AmMBR) are cutting-edge technologies for treating influents of different pollutant concentrations. AmMBR is based on anaerobic digestion technique, which is characterised by stability and microbial availability, as well as strong toxic tolerance, resulting in high EP biodegradation efficiency. In addition, AmMBR can produce biogas in considerably greater amounts than the traditional anaerobic biodegradation method, meaning that the removal of EPs from liquid effluents is increasingly used. Although the efficiency of biogas production in a typical anaerobic process is determined by methanogenic bacteria, solids retention time (SRT), and hydraulic retention time (HRT), but in AnMBR, there is a high and stable cell concentration based on a reasonable high hydraulic load and sufficient mixing as a result of fully decoupling HRT from SRT, since membranes prohibit biomass from being flushed out. The drawback of foulants in AnMBR, as in traditional MBR, is that it limits the flow through the membrane and thus makes it possible to ensure greater membrane sections per reactor volume, with higher capital costs, reducing the application of AnMBR on a larger scale (Lin et al., 2013).

4. Understudied areas of Emerging Pollutants

4.1. Spatial-temporal variability for EPs

Various data and broader studies were used to classify main areas of concern perceived to be underexplored. Both are presented in order to resolve gaps of established understanding of EP pollution of aquatic ecosystems. For certain EPs, a wide difference in prominent sewage composition has been reported. In prominent sewage water, for example, acetaminophen was detected at average amounts varying between 6954 to 462,340 ngl^{-1}(Roberts and Thomas, 2006). In their application, this suggests spatial and/or temporal differences. However, dilution from farm produce, upstream sewage depletion, precipitation and collection modes both will add to this uncertainty (Nakada et al., 2017). The largest drawback is the use of incorrect sampling techniques. Present methods prefer on using lower inter-day frequency isolated grab collection and sometimes no intra-day repeating (Teodosiu et al., 2018). To illustrate, using a grab sampling technique, all recorded information was collected. There are drawbacks of this method since it only provides a visual representation of EP intensity at a given point in time. Differential composite samplers with time and quantity are mostly used (Dimpe and Nomngongo, 2016).

Chemical stabilization is still a greater debate about 24 h composite analysis. This is not often studied, although for certain substances, it is considered to be important. There is a lack of knowledge of spatiotemporal differences in EP concentrations due to inconsistencies in current sampling techniques.

It is extremely difficult to determine the spatial patterns of EP pollution. There are clear drawbacks to the compilation and analysis of research data from a number of references. Research findings, but at the other side, were able to test spatial patterns provisionally within a single river system (Thomaidis et al., 2012). Given the wide sample, such analyses have to depend primarily on selective subjective sampling and range of sites that are tracked at about the same time. Knowledge obtained from such experiments is highly useful, considering the variance with grab sampling. It can be used as a key predictor of locations needing more comprehensive analysis within the river system. To clarify the concept of EP existence and frequency throughout waste, these could then be subjected to more rigorous testing protocols.

4.2. Sampling Uncertainty

The proportions of EPs in the recipient waste water are likely to differ during the day. Hourly mix proportions (i.e. one sample per 15 min to construct an hourly composition) were obtained by (Coutu et al., 2013) for prominent wastewater over 24 h monitoring period (Fig-2). This was used to analyze the variation in antibiotic concentrations in a day. On processing, samples were cooled, but their stabilization at 4^0C was not examined or cited. A rise in the antibiotics content is found after the very first flushing toilet of the day. It is predicted that other urinary dependent EPs would act the same way. Yet it is unclear how the output of treatment plants in receiving accumulation and volumetric loading reacts to this regular increase. It will help to resolve this by gathering related treated water samples (Baker and Kasprzyk-Hordern, 2013). Most studies have shown that monitoring load (volume per day) for the standard concentration method (mass per litre) is more suitable for explaining effects in order to resolve temporal differences in flow (Pro et al., 2003). Even though a single monthly grab sample consisted of the inspection procedures, which significantly limits knowledge of seasonal fluctuations. Temporal differences in antibiotics within strong waste water were explored through a more rigorous method, which conducted weekly 24 h flow relative sampling every month for a one-year duration. In Switzerland, seasonal changes were recorded for both ciprofloxacin and norfloxacin in the reception of waste water for the treatment plants (Veach and Bernot, 2011). There seems to be a lack of information regarding the effect of periodic

events on wastewater loading of EPs, or their effect on the overall efficiency of water treatment and the microorganisms of the receiving area. During music concerts, national holidays, big sports competitions and during exam times for increased focus, there may expect a rise in substance use. There's still insufficient awareness of the ability of sewage treatment plants to preserve regular efficiency in certain situations and to ensure antibiotic elimination. Nonetheless, lab - scale study has shown that traditionally recorded oseltamivir carboxylate amounts (the ace inhibitor of Tamiflu®, the drug used in reaction to an epidemic of influenza) have decreased activated sludge output in terms of nutrient elimination (Vieno et al., 2007).

Seasonal uses of some EPs suggest that their prominent loads differ during the year. For example, monthly prescription data for the United Kingdom showed that antihistamines used to treat allergies (e.g. hay fever) peaked when pollen production was highest between May and August (Fig-3) (Health and Social Care Information Centre, 2011). Similarly the seasonal Variation for Phalcodines were shown to be peaking during the winter months (Fig4). This uncertain behavior of concentration of EPs in different months of the year is an added factor to the uncertainty for sampling of EPs.

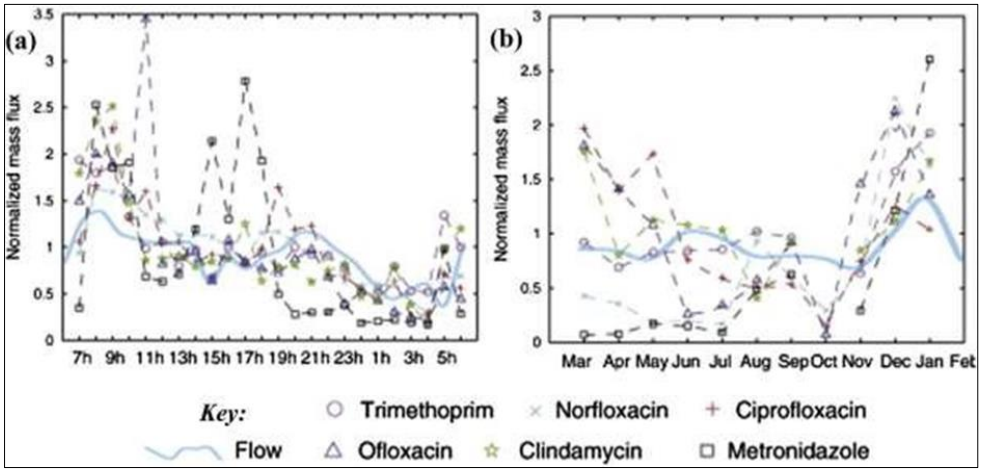


Figure 2 Mass Flux variations of some antibiotics in one day Period (a) and during one year Period (b). Source – (Coutu et al., 2013)

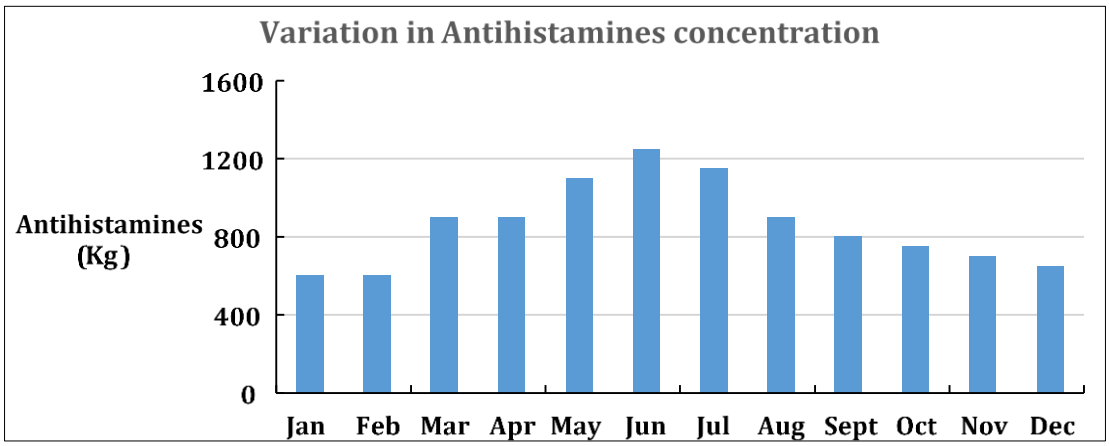


Figure 3 Seasonality variation of Antihistamines

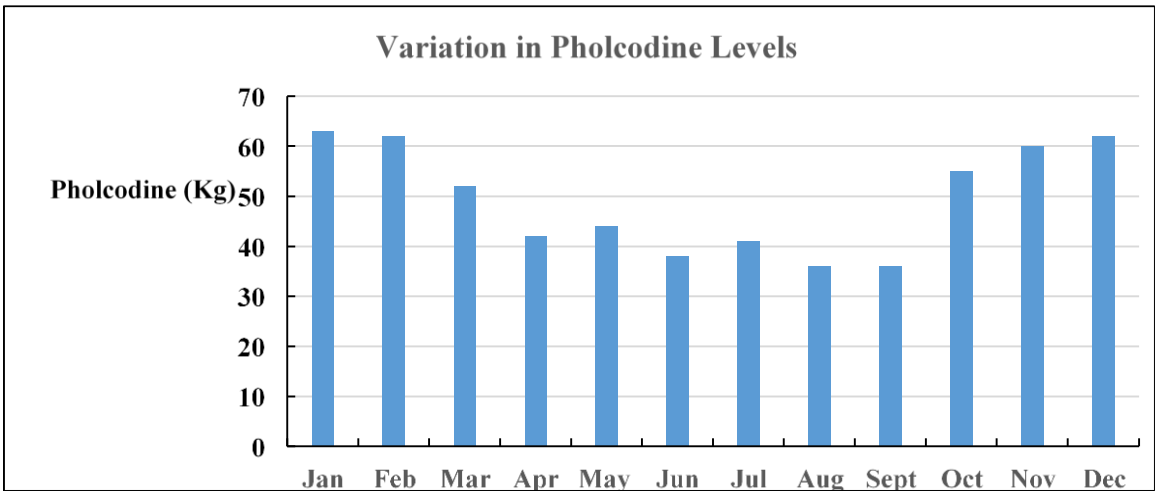


Figure 4 Seasonality Variation of Pholcodine

5. Partitioning and diagnosis during treatment processes of wastewater

As certain compounds have a strong specificity for particulates, research here is important. Several compounds, like citalopram, EMDP, dosulepin, fluoxetine, norfluoxetine, surfactants, ceftriaxone, and ciprofloxacin, were identified to be at substantial levels (>20% if the overall levels) inside the particulate phase of prominent wastewater (Jelic et al., 2011). Subsequently, identification of the particulate phase is important for certain compounds to accurately record influent concentration. Characterized by low levels of solids, the separation of EPs to suspension content in final effluents is also less examined. After all, it is observed that, amid very small suspended particles levels, the ultimate discharge of various process had >20% percent of the overall triclosan, ofloxacin and ciprofloxacin concentration levels was within the particulate phase. The amounts of the particulate phase was equal to and in the region of 26-296 ng l^{-1}, respectively (Yang et al., 2017). This offers a way into the atmosphere for their discharge that goes unsupervised and the persistence in the environment of these substances connected by particulates are unclear.

Particle phase study, as well as biomass evaluation (either suspension or affixed) of the system, is required to better understand their removal mechanisms during water treatment. Preferably, for each sample stage, subsequent aqueous and fine particles determinations can be made in such a manner that a full process mass balance is obtained. This will have convincing information on the persisting mechanisms of treatment. Separation can differ considerably for EPs from biologically controlled metabolic processes to mechanically guided system. Their recognition often needs to be accompanied by process requirements and procedure details, nutrient removal and complementary evaluation of biomass physical/biological characterization (Petrović et al., 2003). The activity of the mechanism could be changed to favor their elimination with this knowledge. This data can also be used to determine where more testing can be carried out. For instance, biodegradation-removed chemicals indicate further analysis of potential biotransformation substances in final effluents. Adsorption removal requires more comprehension of their future in and after the treatment of wastewater.

Biomass (or treated sludge) are produced throughout anaerobic digestion. Most of these are spread in some nations to farm land as a compost. Other EPs are said to survive despite extended digestion (20-30 days) and external preservation for up to six months after treatment. No law explicitly regulates the use of biosolids with regard to the accumulation of EPs on farmland. A lack of research has also been found here. The bulk of previously investigated compounds in biomass were observed to be < 1 mg kg^{-1} (Joss et al., 2006). But at the other side, >1 mg kg^{-1} was registered for bisphenol A, surfactants, triclocarban and the antibiotics amoxicillin, ceftriaxone and norfloxacin. These chemicals have somewhat different physical and chemical properties, meaning that their existence and transfer in modified soils can vary between triclosan and triclocarban, exhibiting larger hydrophobicity ($_{Ka}$w) within the soil matrix, indicating storage. Those that are comparatively water soluble, on the other hand, signify hydrophilic flexibility that may contribute to their transfer to nearby water bodies. Some studies have shown, however that antibiotics indicate a wide variety of soil flexibility. This means other pathways, especially for charged EPs, are prominent (D.R. et al., 2012). Other processes, such as electrostatic interactions, are likely to control the separating activity of charged EPs. If charging interactions play some role in sorption, the principle of $_{Ka}$w here is not important and therefore cannot be extended. In order to fully understand splitting behavior, the acid-dissociation constant (pKa) of the EP in issue and the pH of the matrix also are important. Long-term field research is required in realistic ecological parameters to fully understand the fate of ECs in soil. These

involve monitoring over a prolonged period of time of biomass, soils (pre- often post-application, and at different depths), adjacent aquatic environment, and microbial activity. It will help to explain their destiny by promote the importance on pH, precipitation, temperature, sunshine and soil type/ properties. An appreciable description by (Butler et al., 2011) reported that triclosan (~0.8-1.0 mg kg^{-1}) demonstrated no improvement in intensity over the first eight months for three different types of soil due to the application of sludge. Nevertheless, less than 20 percent of the initial sample was restored after 12 months. The biological transition of triclosan to methyl triclosan was responsible for a significant proportion of this. Up to 0.4 mg kg^{-1} was detected with methyl triclosan, indicating that transition items ought to be examined here.

6. Fate of Emerging Pollutants in environment

Physicochemical processes lead to the elimination of EPs from groundwater and surface water. During treating wastewater, solubilization into biomass or into sediments as found in the river system can result in aqueous medium elimination. It is only likely to retain true with some EPs, though. For illustration, if the balance between the biomass or sediment and the aqueous medium is formed for a given EP, the net interaction between the 2 phases (as well as the elimination from the aqueous medium) is zero. Sorption would also not result in the elimination of them. For certain EPs, such as hormonal estrogens, this was found through sludge treatment systems (Bolong et al., 2009). In the other side, owing to their high tendency for solid organic material, the antibiotics ofloxacin and ciprofloxacin are said to be extracted by sorption throughout treating wastewater. Thus it is important to understand the importance of physicochemical characteristics in sorption these EPs. Evaluation should also be extended to the influence of dissolved organic matter on the environmental fate of EPs.

Emerging contaminants may originate from different points or dispersed sources in the environment and then enter the soil, air or waterways by several means or processes that are largely dependent on the properties of EPs (polarizability, stability, durability, etc.) and the characteristics of environmental media. Through many routes from industry, homes, hospitals, soil, etc., EPs and some of their derivatives are released into the environment and penetrate surface and ground water (Fig-5). When insufficiently treated effluents from wastewater treatment plants are released, EPs can quickly become contaminants to river ecosystems. Because of their durability, they can (bio) accumulate in sediments and stream plants and animals, as their biodegradation, chemical degradation and photo degradation can occur at very limited amounts. As a result, their absence from the aquatic environment is nearly non-existent. Although, certain microbial populations are able to struggle the biocide effect of EPs and feasibly alter them, increasing their degradation rate. There are few studies that examine the gradual biodegradation of EPs, such as hormones, certain pharmaceuticals or detergents.

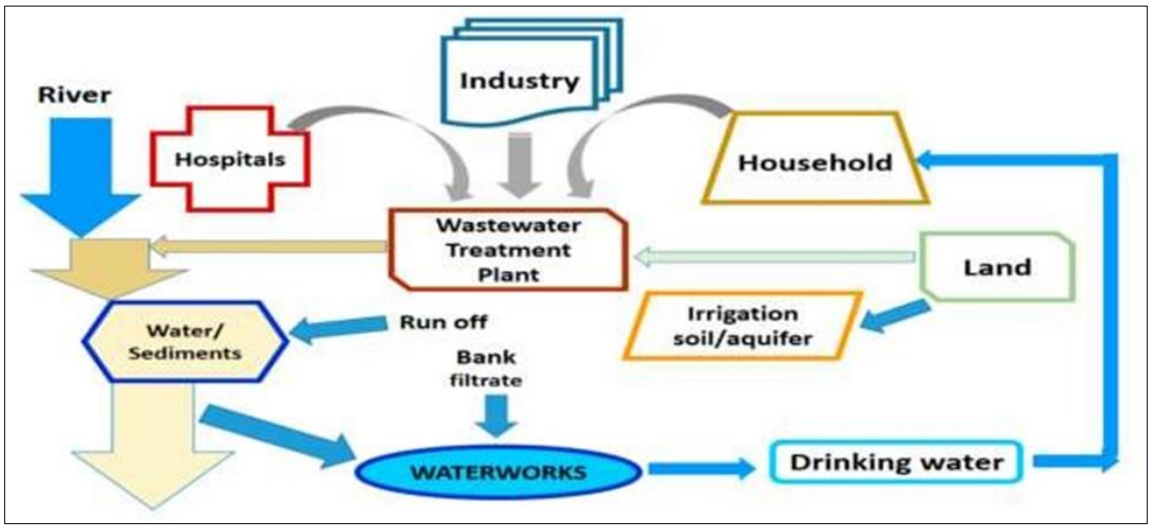


Figure 5 Emerging Pollutants origin and their routes in the environment. (Adapted upon https://www.normannetwork.net/sites/default/files/files/Events/2006-2008/2006Jun19-20-Stresa-EmEnvPollutants1KeyIssuesChallenges/03-sess1_ternes.pdf)

EPs are vulnerable to degradation by photolysis once found in the aqueous medium. A few EPs, such as ketoprofen, propranolol, naproxen, gemfibrozil and ibuprofen, have been effectively degraded by photolysis (Lin and Reinhard, 2005). Half-lives varied generally between 4 minutes for gemfibrozil and ibuprofen to 15 hours for ketoprofen. The variations in their chemical composition are due to this spectrum of vulnerability to dissolution by photolysis. For

instance, ketoprofen's carbonyl movement is paired with two benzene rings, resulting in a very sensitive triple state and a greater vulnerability to photolysis. Photolysis may also make a major contribution to extracting a variety of EPs from surface waters. The elimination of the parent compound by photolysis, as with biodegradation, is not representative of full mineralization and some transition compounds can be detected. Photolysis may also make a major contribution for removing a variety of EPs in surface water. As with biodegradation, the elimination by photolysis of the parent molecule is not representative of absolute mineralization and some transition products can be detected**.** For the elimination of the parent drug, a decrease in toxicity could not be detected. It can be asserted that the existence of relatively high concentrations of dissolved organic matter and also particulates in water bodies would minimize EP kinetic depletion by obscuring the strength of sunlight. However, (West and Rowland, 2012) observed that, depending on the particular EP studied, humic acid (a low molecular weight chemical ion) reduced or improved the biodegradation. Indirect photolysis can be due to accelerated oxidation in the existence of humic acid or nitrates. Environmental considerations such as stream depth, forest shade from the shore, suspended solids concentration and weather also need more study in order to determine their effect on EP photolysis under ecological parameters.

7. Impacts of Emerging Pollutants

The advancement of analytical techniques for the identification of EPs in groundwater and surface water has made it possible to enhance the calculation and environmental evaluation of EPs. It's been demonstrated that a wide range of EPs frequently polluted surface and groundwater at substantial levels, which may theoretically poses serious environmental impacts. The full removal of EPs doesn't really actually occur in water/wastewater treatment plants, considering the developments in water and wastewater treatment technologies and techniques, so the amounts of EPs are already hitting the sources of water. In the past, chronic impacts of some EPs, such as the brief impact of pharmaceutical products on arthropods, have been reported, but the amounts measured were typically greater than the normal ones observed in environmental samples (Focazio et al., 2008). Thus, levels similar to those measured in the environment are more widely used techniques in order to get accurate outcomes. The organisms used and their corresponding tolerance are also essential in such experiments (Jiang et al., 2013). Due to the absence of evidence, they are not clearly known, although the study of the eco toxicological impact of EPs has risen exponentially over the last 15 years. As already stated, only 8 medicinal additives are currently under consideration for their designation as potential priority compounds or priority dangerous substances, a relatively small number relative to the overall number of therapeutic compounds or other classes of pollutants under review (Murray et al., 2010).

It is understood that certain EPs may have biochemical impact on aquatic organisms and habitats. Four separate classes of EPs (antibiotic, antineoplastic, cardiac medications and sex hormones) were tested for aquatic toxicity and have been shown to be vulnerable to these medicinal compounds by daphnids fish, whereas antibiotics and estrogens have been listed as the most toxic products for public health and marine life (Rodriguez-Narvaez et al., 2017). As certain chemical compounds can interact with the normal function of the adrenal glands of many marine and terrestrial animals, aquatic species can be more susceptible than humans to the existence of EPs in water. This intervention can have detrimental effects, including diminished fertility, sexual instability and demographic change. The existence of EPs in the ecosystem is considered to pose a threat mainly to water bodies and their corresponding habitats and marine life, in comparison to human health (Richardson and Ternes, 2018). As certain chemical compounds can interact with the normal operation of the endocrine system of several aquatic and terrestrial animals, aquatic species could be more susceptible than humans to the existence of EPs in water. EDCs are known to be such pharmaceuticals, PCPs, domestic and commercial cleaning products, fire-retardants and pesticides. The endocrine disrupting effects of medicines such as sex hormones, livestock development hormones and antibiotics and corticosteroids are identified, while studies for more drug substances are still underway to find other substances with any of these features (Taheran et al., 2018). Can EDCs disrupt with the production, absorption, transportation, attachment, reduction of the activity of natural hormones in the body responsible for homeostasis.

The involvement of antibiotics in processed sewage effluents and in particular, in marine habitats can improve microorganism tolerance and can have a major effect on bacterial communities. They will interact with the composition of the bacterial environment and so affect the microbial communities and the marine ecosystem's ecological processes. The existence of EPs in the atmosphere is recorded to increase bacterial resistance to antibiotics due to continued introduction of antibiotics into water. In waste water, drug resistant microbes and antibiotic resistant genes are frequently found even at high amounts than in surface water, which implies that wastewater treatment systems lead to the spread of these resistant antibiotic bacteria (Schriks et al., 2010). By sharing genes and various genetic platforms, bacterial species with different backgrounds (e.g. humans or animals) in water may be combined and build tolerance.

A key concern tends to be the existence of pharmaceutical products and PCPs in drinkable water. The pollution of water sources is highly related with the drinking water quality. The fact that these substances pose a hazard to public health

is not yet simply and widely acknowledged. The typical amounts of pharmaceuticals found in drinking water are typically smaller than 0.05 μg/L, which is lower than the actual medicinal doses (Daughton, 2004). Therefore, toxicity levels of drinking water to specific compounds are not recognized as a potential danger to human health and there are no controlled standards for these compounds, but there is a growing risk due to constant and unrestricted pharmaceutical consumption. Daily monitoring of pharmaceutical products should not, also be underestimated, particularly in places where local conditions can contribute to potential higher amounts in water systems.

8. Future recommendations

A testing method is necessary that can: (i) achieve a standardized sample representative of a process over a prolonged period of time and (ii) use an effective preservation technologies to create the stabilization of reagents. While there are technical challenges with the processing of stream samples for the installation of testing instruments at suitable areas around treatment facilities or on waterways, their use is important for obtaining symbolic assessments throughout environmental observation. Conversely, it is interesting to evaluate passive samplers, and these involve further analysis to create their appropriateness for more polar compounds such as EPs. Preferably, actual sensors would be utilized in situ (Richardson and Kimura, 2020). In any case, sampling initiatives for weekends can be at least one week long where significant flow and EP load fluctuations are possible. In order to decide the fate of EPs across treatment structures, study of recycling sludge and stream sediment is necessary. This involves study of the particulate process of all sample locations. Admittedly, this would be impossible to achieve over a full testing project for final details. However, despite the lack of review previously conducted here the assessment of effluent water particulate state levels at minimum once during monitoring campaign is important (Richardson and Ternes, 2018).

Stationary phases consisting of smaller particle sizes (i.e. <2 mm) that can attain ultra-performance liquid chromatography (UPLC) in terms of regular intervals and columns efficiency thus achieving enantiomeric inter phase separation would be helpful. Before their growth, it is proposed to use comparatively quick achiral UPLC procedures assisted by chiral displacements to evaluate enantiomeric fractions as many compounds as possible (Díaz-Cruz et al., 2009). Directed UPLC methods are capable of concurrently determining up to 100 EPs at comparatively short research periods (~10 min) in separate environmental matrices. Optimally, these multiresidue approaches used to test ECs must be complex so that while performing directed (quantitative) assessments, they could conduct non-targeted (qualitative) scanning (Naidu et al., 2016). It is advantageous to use highresolution mass spectrometers such as Orbitrap technologies that can carry out targeted and non-targeted screenings and enable retrospective study. Such equipment allows compounds to be quickly added for eventual qualitative evaluation, not initially used in selective screening but recognized as of significance (Zhao et al., 2018). Good chromatographic isolation depends on the effectiveness of non-targeted screening. Consequently, for the isolation of a wide variety of target EPs reflecting physical and chemical structure extremities, the chromatography process must be optimized. It will help to recognize unknown substances of significant concentrations in conjunction with screening in both positively and negatively ionizing processes. However there are some drawbacks to non-targeted sampling, since the composition of the EPs in issue remains unclear. They may however, not be retrieved mostly during preliminary testing or may not be ionized during the examination. New bioanalytical approaches have to help chemical research, too (e.g., metabolomics). The use of a metabolomics method will provide knowledge at the molecular level on the structure and health of the body (Bundy et al., 2009). Conventional toxicity tests that focus on end - points such as rise, mortality and regeneration for a small range of indicator species will otherwise lack such data.

It is expected that this will begin to discover new substances. Future studies must concentrate on discovering the contaminants that represent the biggest risk to people and habitats, thus reducing associated consequences. The current research goals should be to classify new pollutants and their possible new origins and mechanisms, and to continuously improve monitoring and laboratory instrumentation strategies down to trace amounts. In addition, in order to efficiently eliminate as many EPs as possible, drinking water and wastewater disposal systems can be further strengthened and if required, re-designed. The latest evidence available is sparse and does not encourage global conclusions to be drawn. The impact of long-term toxicity and the consequent effect on marine organisms of individual or even several EPs could be measured safely, while the observation of toxicity results collected at greater quantities than those in nature does not include the appropriate characteristics. Present understanding of the existence of most EPs in the world, in a few terms, does not enable for the estimation of quantities, levels of toxicity and consequences. Therefore the control of these substances is technically problematic since the prescribed values observed are not yet available. In order to deepen our knowledge of EPs fate and transition mechanisms, field studies and laboratory studies are required. In addition, as the efficiency of wastewater treatment plants in the elimination of antibiotic resistance is still not effective, further studies should be undertaken to resolve the numerous questions that still remain.

9. Conclusion

Environmental legislations are likely to be extended to include a variety of EPs originating from communities.

However, there is still a lack of clear awareness of their fate during waste water treatment and within the ecosystem. There are concerns about the confirmed extraction of EPs by treatment facilities due to the shortcomings of commonly used sampling techniques. Thus with acceptable sampling techniques, the removal efficiency of different kinds of treatment processes at various operating conditions needs to be re-evaluated. This will help to decide the measures appropriate for EP progress. The increasing movement towards implementing strategies and lowering energy requirement for waste water management would lead to a growth in the use of innovative treatment methods. Algae ponds for secondary effluent cleaning, for example, are a promising form of treatment that can indirectly generate energy by biogas processing. There are very few reports, however, that have tracked their success for EP elimination. To decide the fate and elimination of EPs throughout treatment, further studies of such processing steps are required given their system application in the traditional treatment report form. A comprehensive approach must also therefore be extended to environmental monitoring. This involves determining the destiny and effect of EPs, including the terrestrial environment, during their full life cycle. For instance, it is important to quantify biosolids and adjusted soils for their existence, as well as to help research. Comprehensive studies of transformed soils under environmental conditions are needed to analyze leaching and drainage, the effect on the quality of surface water, soil depletion, toxicity to terrestrial species and the possible absorption of plants and entrance into the food web. For tracking other polluted environmental compartments, such as river sediments, a related method may be implemented. Eventually, the integrated use of biochemical assessment to properly evaluate the effect of EPs on the atmosphere would allow more detailed environmental risk evaluation to be reviewed and created.

Compliance with ethical standards

Acknowledgments

Professor Puneet pal Singh Cheema for his support during the writing of this review.

Disclosure of conflict of interest

The authors declare no conflicts of Interests.

Funding Source

No specific grants were received from funding agencies in the commercial, public, or not-for profit sectors.

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