Persistent Organic Pollutants (POPs) in The Sea: A Review

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Abstract. Persistent Organic Pollutants (POPs) are organic compounds that have been banned or restricted for all purposes. Banning these compounds does not guarantee that the chemicals will not be found in the environment. This is related to the persistence nature of POPs. To investigate the presence of POPs in the environment, Environmental monitoring of POPs is one of the efforts to support POPs management. The most frequently discussed pollutants in the last 3 years are polychlorinated biphenyls (PCBs). In addition, an effective method in degrading Persistent Organic Pollutants is the fabrication of ultra-thin graphitic carbon nitride decorated CoFe2O4/Mn3O4 nanosheet membranes with a yield of 94.5% and a kinetic rate (0.1367 min.-1) for norfloxacin (NOR) within 30 minutes. But for a method that uses simple, efficient and affordable technology to remove organic pollutants from aquatic systems is Biosorption using biomass waste, using tannin-rich waste such as coffee grounds and green tea grounds capable of degrading 10 μM chlordcone.

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1 Introduction

Rapid industrialization and globalization are addressing the growing needs of humanity, which have become essential components of growth. At the same time as those endeavors have contributed to the fantastic advancement of human society, they've additionally brought on good sized environmental infection via the discharge of rather hazardous waste substances. those noxious byproducts no longer only pose a giant risk to the environment but also jeopardize the properly-being of the human population [1]. Marine pollution can result from waste disposal occurring anywhere, but some of it may be disposed of in marine areas. The ocean's greater area than the land on Earth has led many to utilize it for various benefits. The ocean's role as a food source is one of its benefits. Consumption of marine fish can offer protein, critical nutrients, minerals, trace factors and lengthy-chain omega-3 polyunsaturated fatty acids however, the disposal of waste has led to marine pollution which might be unfold globally, inflicting problems together with continual natural pollution (POPs). Marine fish, which can be at first very nutritious, can be suffering from these continual natural pollution, which can also cause fitness issues for humans [2].

Persistent organic pollutants (POPs) are one of the predominant examples of chemical pollutants that pose crucial dangers and stresses for the complete planet and are the silent killers that are ubiquitous in our environment including in human, plant, and animal tissues [3]. POPs are also poisonous chemical substances that continue to be fairly strong inside the surroundings for long durations of time, are geographically distributed round the sector, accumulate in the fatty tissues of dwelling organisms, and are poisonous to human and natural world fitness [1]. In different phrases, persistent organic pollution (POPs) are organic compounds which can be present in marine environments round the arena due to their resistance to environmental degradation. Their excessive lipophilicity makes them able to bioaccumulating in massive quantities within the tissues of marine organisms [4]. Marine waters are suffering from continual pollution that continue to be for lengthy intervals of time and come to be to be had to marine biota, main to a negative impact on population and individual health after they reach them thru water or atmospheric shipping. that is in particular relevant in coastal marine waters, that are mainly susceptible to chemical pollutants [5].

The surroundings incorporates various POPs, and their toxicity varies. POPs are normally of kinds: Intentional POPs and unintended POPs [6]. Examples include dibenzo-polychlorinated P-dioxins and dibenzofurans (PCDD/Fs) which can be accidental, and polychlorinated biphenyls (PCBs) and polybromodipheyl ethers (PBDEs) which can be man-made chemical compounds. The toxicity of the previous makes them nonetheless a priority circle of relatives for environmental monitoring. PCBs are produced and launched in big portions through their use in transformers, electrical device, hydraulic fluids, paints, sealing substances, and different merchandise. the ongoing interest in measuring the environmental destiny of PBDEs, which can be flame retardants determined in a extensive variety of consumer products, is justified. those pollution can be bioaccumulated by using marine species whose consumption, in flip, may also pose dangers to different species and in the end to human beings [3].

POPs can purpose damage to organisms in each persistent and acute approaches, together with diabetes, obesity, reproductive disorders, neurological problems, most cancers, and damage to the liver, kidneys, lungs, and fearful machine. Organisms can be uncovered to both natural and artificial chemical substances via meals, injuries, or the environment, and this publicity is damaging as it could motive genotoxicity, ecotoxicity, immunotoxicity, reproductive toxicity, and persistent toxicity [1]. Moreover, their poisonous consequences in
addition to their chemical-physical traits give them the ability to carry out long-distance transportation and worldwide distribution, go through bioaccumulation and biomagnification thru food webs and persist in all elements of the environment, making POPs a class of chemical substances that require continuous environmental monitoring and studies [3]. Further, persistent organic pollution are chemical compounds which might be harmful to the environment with residences inclusive of: persistent houses (which are not easily degraded through chemical, physical or biological approaches), are toxic to dwelling organisms, are able to pass speedy to different environments, and feature low solubility in water but are very soluble in fats, so it's miles very easy to contaminate through the meals chain [7].

Ongoing and newly rising organic contaminants and their breakdown byproducts are continually being discharged into the environment. they are always detected no longer most effective in wastewater however additionally in wetlands, water elements, or even in consuming water. This gives a great international hazard to each human health and the properly-being of ecosystems. Aquatic habitats are beneath growing scrutiny because of the buildup, toxicity, and ability environmental dangers associated with chronic natural pollutants (POPs). these harmful materials are generated in substantial volumes and regularly added into aquatic ecosystems [1]. Various techniques for removing persistent organic pollutants need to be developed. Fungi, bacteria, and other devices have been created to degrade persistent organic pollutants.

2 Methodology

The research method used for making this journal review is the comparative method, namely by collecting various sources obtained from research journals. The theories used to solve the problem under study are obtained through literature review using primary data. Searching for English and Indonesian research journals or international and national journals using Google Scholar, Science Direct, PubMed, and related and recent scientific journals with a limit of 2020-2023 publication years. The keywords used include "Marine pollution" and "Persistent Organic Pollution".

3 Results And Discussion

3.1 Content of Persistent Organic Pollutants

Persistent organic pollutants are one of the Endocrine Disrupter Compounds (EDCs) which is a compound that disrupts the function of endocrine hormones that can interfere with reproduction, metabolism, growth and make immunity dysfunctional. The negative effects of persistent organic pollutants can affect one individual, but can affect the entire population [7]. Based on the results obtained from several journals that have been discussed by several experts, the resulting Persistent Organic Pollutants can be implicated in several populations such as polar bears, dolphins, birds, and sharks. Take a look at table 1 below:

<table>
<thead>
<tr>
<th>Content</th>
<th>Effects</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Polychlorinated Biphenyls (PCBs)</td>
<td>Endocrine disruptors</td>
<td>[8]</td>
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<tr>
<td>Dichlorodiphenyltrichloroethane (DDT)</td>
<td>Endocrine disruptors</td>
<td>[9]</td>
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<tr>
<td>Persistent Organic Pollutants</td>
<td>Impact</td>
<td>Source(s)</td>
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<tr>
<td>Polybrominated Diphenyls Ether (PBDE)</td>
<td>Cognitive development disorder</td>
<td>[10] [2]</td>
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<tr>
<td>Organochlorine</td>
<td>Endocrine disruptors</td>
<td>[11]</td>
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<tr>
<td>Hexachlorobenzene (HCB)</td>
<td>Endocrine disruptors</td>
<td>[12]</td>
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<tr>
<td>Polycyclic Aromatic Hydrocarbon (PAH)</td>
<td>Endocrine disruptors</td>
<td>[13]</td>
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<tr>
<td>Polychlorinated Dibenzo-p-dioxin (PCDD)</td>
<td>Endocrine disruptors</td>
<td>[3]</td>
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Based on the table above, there are several impacts that show the disturbance of Persistent Organic Pollutants that have been reviewed based on journals as follows: Population decline in several marine mammals such as risso dolphins, male polar bears, sturgeon due to reproductive dysfunction and immunosuppression caused by Hexachlorobenzene (HCB) [12]. The population of male polar bears decreases when they are exposed to PCBs because it negatively impacts their ability to reproduce, resulting in fewer changes in their mating behaviour. The mobilization of stored body fats leads to this phenomenon during lipophilic periods. Persisting organic pollutants are released by adipose tissue, which then become bioavailable, remobilize in the blood, and reach vulnerable organs like the thyroid, adrenal glands, gonadal system, and central nervous system. [14]. Arctic species, including this male polar bear, is concerned about peak exposure to starvation-related POPs during the reproductive season since endocrine glands and the central nervous system are essential for reproduction. [8].

The Persistent Organic Pollutant compound DDT (Dichlorodiphenyltrichloroethane) caused anthropogenic stress that resulted in decreased reproductive success and adult survival of polar bears. The storage in seawater and ice can lead to the emergence of both old and new Persistent Organic Pollutants due to climate change. The melting sea ice caused by climate change could make it harder for polar bears to hunt for seals on the ice. The bears may need to change their diet and store less adipose tissue, resulting in an increase in lipophilic substances like POPs. Extended fasting intervals may elevate DDT concentrations, which may cause a rise in mortality and a decline in the success of reproduction [15].

Multipled concentrations of PBDEs and PCDDs seem like with ease processed through the liver even as gathering in muscle tissues, which clarifies why PBDE concentrations had been detected inside the muscle tissue of european blue sharks. The role of plastics and microplastics as a supply of flame retardants and different chemical substances has had a enormous impact on the levels of PBDEs and PCDDs inside the ocean. This have an effect on is predicted to persist through the years, often because these materials migrate into the marine environment, specially whilst aided by using the digestive fluids of marine organisms. these PBDEs and PCDDs are then bioaccumulated by marine species, and whilst those species are consumed, it may pose a threat to other species and in the end to people. [2]. Therefore, as elasmobranch species, including sharks tend to occupy high trophic levels in food webs, they are susceptible to biomagnification from elevated Persistent Organic Pollutant loads, and are therefore one of the most substantial sources of risk to human seafood consumers [10].

Research is centered on sediments due to the ecology of sturgeon, specially in terms of reproduction and foraging. exposure to Polycyclic fragrant Hydrocarbon (PAH) and Organochlorine (OC) concentrations in sediments can set off oxidative pressure, adjustments in genotoxicity, and histopathology that can reason mental defects, lessen metabolism and cardio increase, and disrupt replica in sturgeon. Sturgeon reproduction occurs in rivers close
to the riverbed. Throughout this era, fertilized eggs expand a sticky quality, adhering to any available surface, together with aquatic plant life, rocks, and coarse sediments. Younger sturgeon, in their larval segment, carefully engage with the sediment and feed on insect larvae, along with chironomids. Sturgeon are benthic fish that inhabit the area near the sediment-water boundary. The pollutants identified within the Dordogne and Garonne Rivers broadly speaking include hydrophobic materials like Polycyclic aromatic Hydrocarbons (PAHs) and Organochlorines (OCs)[13].

HCB, DDT and PCB degrees are higher inside the rhenian Tyr Sea, which also can be considered the most critically affected vicinity from an anthropic point of view because of high levels of marine traffic, subsequently a contaminant hotspot. A study of the ecotoxicological evaluation of grownup male Risso's dolphins stranded on Elba Island (Italy) confirmed excessive concentrations of natural chlorine tiers within the adipose tissue, in addition to better degrees of DDT and PCBs. This study resulted inside the discovery of high levels of HCB: in addition, the effects of the a couple of paired contrast take a look at for HCB showed that the evaluation of brain to fats was sizable at the 10% level [12]. At both character and population tiers, duplicate and fitness can be impacted by means of the latter.

A number of these contaminants are regarded endocrine disruptors, consisting of dichlorodiphenyltrichloroethane (DDT) and its metabolites, some polychlorinated biphenyls (PCBs) and hexachlorobenzene (HCB) that purpose damaging health results, including reproductive disorder and immunosuppression [16].

3.2 Methods of Reducing Persistent Organic Pollutants

Non-stop emissions of persistent and newly rising natural contaminants, as well as their breakdown byproducts, consistently input the environment and are consistently detected in various locations, including wastewater, wetlands, water resources, and even consuming water. This affords a massive and global hazard to both human health and the nicely-being of ecosystems. The presence of chronic natural pollution (POPs) in aquatic environments increases widespread concern because of their dispositions to build up, their poisonous homes, and their potential environmental risks [17]. The every day manufacturing of those pollution is large, and they're continuously discharged into aquatic ecosystems. The demand for green wastewater purification techniques has grow to be increasingly more urgent as industrial activities amplify within the 21st century. Many industrial operations produce and release dangerous waste streams that incorporate numerous substances, inclusive of dyes, prescribed drugs, insecticides, surfactants, heavy metals, and others. those materials probably pose risks to the nearby environment [18]. Many experts have developed or created new methods in response to this problem. The following are the methods that exist at present:

<table>
<thead>
<tr>
<th>Methods</th>
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<tr>
<td>Biosorption using biomass waste</td>
<td>[19]</td>
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<tr>
<td>Adsorbents and catalysts using metal-organic frameworks (MOFs)</td>
<td>[20]</td>
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<tr>
<td>Sonoelectrochemistry</td>
<td>[18]</td>
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<tr>
<td>Fabrication of ultra-thin graphite carbon</td>
<td>[21]</td>
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Human and ecosystem health is at risk from persistent organic pollutants that pose a serious and global threat. Simple, efficient, and affordable technologies can be utilized to remove organic pollutants from aquatic systems to address this. The design of this biosorbent necessitates the use of biomass waste that is natural, inexpensive, and abundant. "Dehydrated root fabric sourced from invasive non-native plant species (Eichhornia crassipes, Pistia stratoideal, and Fallopia japonica), in addition to waste merchandise wealthy in tannins including used espresso grounds and green tea grounds, had been hired as biosorbents to assess their effectiveness in casting off generally used organic contaminants, consisting of natural UV filters, pesticides, and herbicides. The adsorption kinetics for every biosorbent/pollutant mixture were defined the use of a pseudo-2d-order model. Remarkably, whole removal of 10 μM chlordecone (100±0%) become viable, a locating of particular importance for individuals dwelling in chlordecone-infected regions (a compound classified as an organochlorine)[19].

Two methods for addressing persistent organic pollution (POPs) contain utilizing biomass waste as biosorbents and using natural steel-based adsorbents and catalysts. some of the primary sorbents which have passed through large studies, activated carbon (AC), organo-zeolites, alkylsilane-modified silica, and polymer resins have emerged as promising adsorbents for the removal of natural molecules from aqueous answers. metallic-natural Frameworks (MOFs) are specially attractive for adsorbing POPs like insecticides because of their numerous chemistry, awesome chemical and bodily stability, adjustable pore structures, and the potential for incorporating practical businesses. One remarkable example is mesoporous Chromium-primarily based MIL-101, which can be hired as an adsorbent in a set-mattress system to continuously put off diazinon from aqueous solutions, a recognized carcinogenic and poisonous substance. MIL-a hundred and one changed into suggested to get rid of 92.5% of diazinon from a solution with a awareness of 150 mg/L. Cr-based MOFs verified constant efficiency in elimination. In contrast to zeolite, AC, or USY, Cr-based totally MIL-101 exhibited extensively better adsorption capability and faster adsorption [20].

The use of a sonoelectrochemical method to treat wastewater that contains clortetracycline antibiotic. Up to 98% of cortetracycline was degraded in solution by using Ti-PbO2 as both the anode and the cathode in the combined sonoelectrochemical method. An important finding was that the total organic carbon removal yield was low (37.2%), indicating that only a small portion of the organic matter in the wastewater was fully mineralized in the process [18].

The integration of SR-AOPs (Sulfate Radical-advanced Oxidation techniques) and separation membranes has been extensively discussed due to their effective and price-green capability in eliminating continual poisonous micropollutants. however, a big task stays in developing incorporated membranes with superior self-cleansing houses, catalytic pastime, and long-time period sturdiness. in this examine, a unique Fenton-like heterogeneous catalyst (MO/CFOUCN) was created for the first time by way of anchoring CoFe2O4 (CFO) and Mn3O4 (MO) nanoparticles onto ultra-skinny graphite carbon nitride nanosheets (UCN) the use of a solvothermal approach. Systematic characterization showed the successful instruction of powder catalysts with robust degradation performance. substantially, the optimized composite catalyst exhibited astonishing degradation efficiency (94.5 %) and a
speedy kinetic price (zero.1367-1) for norfloxacin (NOR) inside just 30 minutes. An incorporated MO/CFO/UCN membrane became fabricated at the assist membrane surface the use of vacuum-assist catalyst filtration. apparently, the mixture of in-situ oxidation and membrane filtration harnessed synergistic outcomes, enhancing the activation of peroxynonsulfate (PMS). This method resulted in the membrane accomplishing a high removal rate (over 91.8%) for substances like tetracycline, bisphenol A, and humic acid (HA), along side a high permeation flux (332.7 L·M-2·H-1), all pushed completely by way of gravity. Moreover, after filtering an HA answer, the membrane exhibited a remarkable flux healing charge of 91.9%, way to PMS. Each radical and nonradical pathways contributed to the mineralization of NOR, as confirmed via quenching experiments and electron paramagnetic resonance (EPR) checks. The detection of intermediates during the degradation technique caused the suggestion of ability pathways for NOR degradation." [21].

AOT or advanced Oxidation era, is employed to interrupt down cussed and resistant natural pollutants determined in wastewater. Electrochemical technology is some other effective method for thoroughly degrading refractory pollution in industrial wastewater. AOT is an rising, simple, value-efficient, and environmentally pleasant technique that does not produce secondary pollution. it's miles tremendously powerful in breaking down tough organic pollutants like fragrant amines and polycyclic fragrant hydrocarbons (PAHs). AOT operates by way of generating robust oxidizing agents immediately on-web site, along with reactive oxygen species including singlet oxygen (O2), hydroxyl radicals (OH), superoxide radicals (O2-), sulfate radicals (SO4-), and holes (h+). these sellers can oxidize considerable amounts of contaminants, in the long run changing them into CO2, H2O, and inorganic ions. In wastewater remedy centers, AOT is normally used to supply organic water free of contaminants for human consumption. Hydroxyl radicals are typically used the use of methods together with ozone, hydrogen peroxide (H2O2), oxidants, and mixtures of oxidizing retailers like ozone (O3) and hydrogen peroxide (H2O2), as well as diverse forms of irradiation (UV, ultrasound, microwave, gamma rays, and so on.), catalysts, or electrochemical reactions. those combos can generate hydroxyl radicals via techniques like ozonation, Fenton reactions, and AOT-based totally photograph-Fenton reactions. Hydroxyl radicals also can be produced in-situ via the oxidation of water or hydroxide ions and through sulfate radicals. [1].

Fungi exhibit the functionality to break down persistent natural pollutants (POPs) while exposed to suitable environmental conditions because they're engaged in processing stubborn carbon compounds. In assessment to bacteria, fungi are favored for this reason because of their greater resilience to environmental toxins, attributed to their various surroundings-related traits. Bioremediation of organic pollutants inside the environment can be accomplished by using wooden-decaying basidiomycetes. A complete examination changed into carried out, involving the assessment of 320 isolates of basidiomycetes from 74 distinct species to assess their boom rates and efficacy in degrading organic dyes. The ability for decolorizing dyes become located to vary both amongst and inside species. moreover, an in depth genome-wide analysis of gene households turned into done at the maximum talented fungal species in phrases of dye decolorization. This analysis brought about the identification of improved gene families, encompassing genes associated with magnificence II peroxidases, DyP-type peroxidases, carbohydrate-active enzymes (CAZymes), oxidation-discount enzymes, hydrophobins, and secreted peptidases. This examine contributes novel insights into the elimination of continual natural pollution by means of fungal isolates, considering each their observable traits and genetic attributes." [22].
4 Conclusion

The pollution of persistent organic pollutants in the world's oceans is very diverse. Based on a review of existing journal articles, Persistent Organic Pollutants in the world's oceans include Polychlorinated Biphenyls (PCBs), Dichlorodiphenyltrichloroethane (DDT), Polybrominated Diphenyls Ether (PBDE), Organochlorine Insecticides (OCs), Hexachlorobenzene (HCB), Polycyclic Aromatic Hydrocarbon (PAH), and Polychlorinated Dibenzo-p-dioxin (PCDD). Polychlorinated biphenies (PCBs) are the pollutants that are most frequently discussed. Man-made pollutants called PCBs are used in transformers, electrical equipment, hydraulic fluids, paints, sealing materials, and other things, resulting in contamination of many populations. In addition, an effective method in degrading Persistent Organic Pollutants is the fabrication of ultra-thin graphitic carbon nitride decorated CoFe$_2$O$_4$/Mn$_3$O$_4$ nanosheet membranes with a yield of 94.5% and a kinetic rate (0.1367 min. $^{-1}$) for norfloxacin (NOR) within 30 minutes. But for a method that uses simple, efficient and affordable technology to remove organic pollutants from aquatic systems is Biosorption using biomass waste, using tannin-rich waste such as coffee grounds and green tea grounds capable of degrading 10 μM chlordecone.

Thanks to all the literature references that have helped provide information and the lecturer of the course "maritime chemistry" who has facilitated all matters in the making of this article.

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1. capable of degrading 10 μM chlordecone.

2. using biomass waste, using tannin

3. Organic Pollutants is the fabrication of ultra

4. contamination of many populations.

5. Hexachlorobenzene (HCB), Polycyclic Aromatic Hydrocarbon (PAH), and Polychlorinated

6. Polybrominated Diphenyls Ether (PBDE), Organochlorine Insecticides (O

7. include Polychlorinated Biphenyls (PCBs), Dichlorodiphenlytrichloroethane (DDT),

8. on a review of existing journal articles, Persistent Organic Pollutants in the world’s oceans

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