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The Effect of Industrial Wastewater on Seawater Pollution

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Abstract

Water pollution represents a significant global challenge, posing a threat to the health and well-being of humans, plants, and animals. The Mediterranean Sea stands out as one of the world's most crucial water bodies, surrounded by nineteen countries and hosting over ten thousand distinct species. This marine ecosystem is vital for millions of people, meeting their nutritional, functional, and recreational needs and serving as a crucial habitat for the nourishment and reproduction of numerous endangered species. Marine pollution results from the introduction of substances or energy into the marine ecosystem through human activities, leading to adverse effects on living resources, endangering human health, and impacting maritime activities. The Mediterranean Sea is anticipated to face substantial impacts due to human activities, with rapid industrial growth and population expansion in coastal regions contributing to the proliferation of domestic and industrial pollutants, thereby creating health, economic, and environmental challenges. Long-term environmental repercussions of unregulated industrial discharges are frequently disregarded in economic assessments concerning costs and benefits. Nonetheless, mounting evidence indicates the accumulation of hazardous industrial by-products in marine organisms. This issue, coupled with the detrimental effects of pollution on recreational pursuits like swimming, surfing, and fishing, raises significant concerns. Industrial wastewater undergoes treatment to eliminate pollutants through diverse methodologies and mechanisms tailored to specific needs. Treatment approaches are categorized into distinct or integrated physical, chemical, and biological methods. Consequently, this paper aims to provide an in-depth examination of marine pollution, its various forms, impacts, and disposal techniques.

Keywords: *Marine pollution, Industrial waste effects, Physical and chemical parameters, Heavy metals*.

الملخص

تلوث المياه يمثل تحدياً عالمياً كبيراً، حيث يشكل تهديداً لصحة ورفاهية الإنسان والنباتات والحيوانات. يبرز البحر الأبيض المتوسط كأحد أهم الأجسام المائية في العالم، محاطاً بتسعة عشر دولة وموطناً لأكثر من عشرة آلاف نوع مميز. هذا النظام البيئي البحري حيوي بالنسبة لملايين الأشخاص، حيث يلبي احتياجاتهم الغذائية والوظيفية والترفيهية ويعتبر موطناً أساسياً لتغذية وتكاثر العديد من الأنواع المهددة بالانقراض. ينجم تلوث البحار عن إدخال مواد أو طاقة إلى النظام البيئي البحري من خلال الأنشطة البشرية، مما يؤدي إلى تأثيرات سلبية على الموارد الحية، ويهدد صحة الإنسان، ويؤثر على الأنشطة البحرية. من المتوقع أن يواجه البحر الأبيض المتوسط تأثيرات كبيرة نتيجة للأنشطة البشرية، حيث ساهم النمو الصناعي السريع والتوسع السكاني في المناطق الساحلية في انتشار الملوثات المنزلية والصناعية، مما يشكل تحديات صحية واقتصادية وبيئية. غالباً ما يتم تجاهل العواقب البيئية طويلة الأمد للتصريفات الصناعية غير المنظمة في التحاليل الاقتصادية المتعلقة بالتكاليف والفوائد. ومع ذلك، هناك أدلة متزايدة تشير إلى تراكم المنتجات الثانوية الصناعية الخطرة في الكائنات البحرية. هذه المسألة، جنباً إلى جنب مع التأثيرات السلبية للتلوث على الأنشطة الترفيهية مثل السباحة وركوب الأمواج وصيد الأسماك، تثير مخاوف كبيرة. تتعرض مياه الصرف الصناعي للعلاج وإزالة الملوثات من خلال منهجيات وآليات متنوعة ومتكاملة حسب الحاجة. تُصنف طرق العلاج إلى طرق معالجة فيزيائية وكيميائية وبيولوجية منفصلة أو

متكاملة، ولذا فإن هدف هذه الورقة هو تقديم دراسة مفصلة حول تلوث المياه البحرية، وأنواعه، والأضرار التي يسببها، وطرق التخلص منه.

الكلمات المفتاحية: التلوث البحري، آثار النفايات الصناعية، العوامل الفيزيائية والكيميائية، المعادن الثقيلة.

INTROCUCTION

The industrial sector is a vital and rapidly developing field. It is the primary sector that uses a large number of raw materials and is also the main contributor to significant environmental pollution. The issue of industrial pollution is one of the most pressing challenges facing the institutions, along with nation, especially in the contemporary era. All executive industrial management, seek to identify the optimal solution to this dilemma through effective cooperation between these executive entities and bodies, recognizing industrial management as a pivotal and influential partner in formulating and implementing the pollution control initiative. The volume of wastewater generated globally from petroleum refining operations is estimated at about 6,700,000 cubic meters per day, as a result of the discharge of industrial wastewater laden with many hazardous pollutants resulting from the operation of various production units, especially when this water is not treated in accordance with strict environmental laws and conditions. Therefore, in compliance with these strict environmental laws and regulations, each industrial facility is mandated to establish units or facilities dedicated to treating the industrial wastewater it produces. The volume and characteristics of the industrial wastewater generated are mostly influenced by the nature of the processes taking place within the production units and facilities independently. The petrochemical sector is one of the most important industries capable of reusing treated industrial wastewater [8].

RESEARCH OBJECTIVES

1-To identify the types of pollutants, present in industrial wastewater.

2-To investigate the impact of these pollutants on seawater quality.

3- To assess the environmental and health risks associated with seawater pollution.

DEFINITION OF INDUSTRIAL WASTEWATER

Industrial wastewater refers to the liquid waste generated from processes involved in the production of raw materials. This wastewater is a by-product of various activities such as washing, cooking, cooling, heating, extraction, physical interaction, separation, transportation, and disposal of liquid waste. It is estimated that approximately 85 to 95 percent of the water used in these various processes eventually turns into wastewater. Industrial wastewater typically includes a minimal amount of domestic sewage generated by plant employees or rainwater collected from plant buildings [9].

TYPES OF INDUSTRIAL WASTE

Industrial waste relates to the systematic management of wastewater generated from: various industrial processes. There are several categories of industrial waste, which include Liquid waste: This includes water produced during industrial processes, such as cooling and disinfection activities. Solid waste: This relates to solid waste generated from manufacturing processes, including materials such as metal or plastic by-products. Gaseous discharge: This includes gaseous emissions generated from industrial activities, including gases produced through combustion processes. Chemical waste: This refers to water contaminated with chemicals used in industrial processes. Biological waste: This relates to waste generated from biological processes, such as wastewater generated in food processing facilities.

CAUSES OF HARM

1- Chemical Pollution: The most harmful form of industrial waste affecting marine environments is chemical waste. This category of discharge includes a variety of harmful chemicals, including heavy metals, organic solvents, and other toxic substances, which can profoundly affect the marine ecosystem, negatively impacting marine organisms and their habitats.

2- Poisoning of Marine Organisms: The accumulation of toxic substances within the physiological systems of marine organisms can lead to poisoning, thus affecting the integrity of the food chain.

3- Destruction of Marine Habitat: Some chemical agents have the potential to irreparably damage the natural habitats that support marine organisms.

4- Long-term Effects: The repercussions of chemical pollution can persist for long periods, complicating efforts to restore ecological balance.

POLLUTION DEFINITION:

Pollution is any change, whether physical, chemical or biological, in the quality of water that adversely affects living organisms or makes water unsuitable for its intended uses. Marine pollution has emerged as an increasingly widespread phenomenon. Its manifestations are not uniform and vary geographically. The degree of pollution also depends on the original source of the phenomenon. Pollution indicators are increasing, driven by population growth, increased urban density in cities and ports, as well as the spread of large-scale marine vessels [11].

DEFINITION OF POLLUTANTS:

The concept of pollutant can be difficult to define because it applies to a wide range of substances, including hazardous industrial by-products. Defining marine pollutants becomes clearer when considering their consequences: any substance that leaks into the oceans and produces harmful effects. This broad definition includes heavy metals such as mercury, synthetic organic compounds including chlorinated pesticides, flame retardants, and polychlorinated biphenyls, as well as some essential life-sustaining substances such as nitrogen and phosphorus compounds. These pollutants have the potential to penetrate the oceans. The degradation of marine ecosystems is often attributed to the confluence of these pressures rather than to a single causative agent [7]. According to the United Nations Environment Programme, any physical, chemical, organic, or radioactive substance present in wastewater that reduces the quality or usefulness of that water and poses a risk to its use is classified as such [8]. Physical change: Changes that occur in the properties of water include differences in aspects such as color, flavor, odor, electrical conductivity, hardness, thermal conditions, turbidity, and the presence of suspended particles.

Biological change: relates to the characteristics and quantities of microorganisms including bacteria, parasites, fungi and viruses that can be detected within these waters.

Chemical change: entails modifications in the chemical composition, properties and concentrations of minerals, electrolytes, salts, pH and alkalinity levels, as well as other chemical

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and radiological properties. Industrial wastewater represents an important source of pollution that poses a threat to public health and the environment in general due to its containing many "critical" physical, chemical and biological pollutants. Figure (1) shows the most important paths taken by pollutants to reach seas and water bodies.
Figure (1): The most important routes that pollutants take to reach the seas and bodies of water. And Table (1): shows the most important pollutants found in industrial wastewater [8].

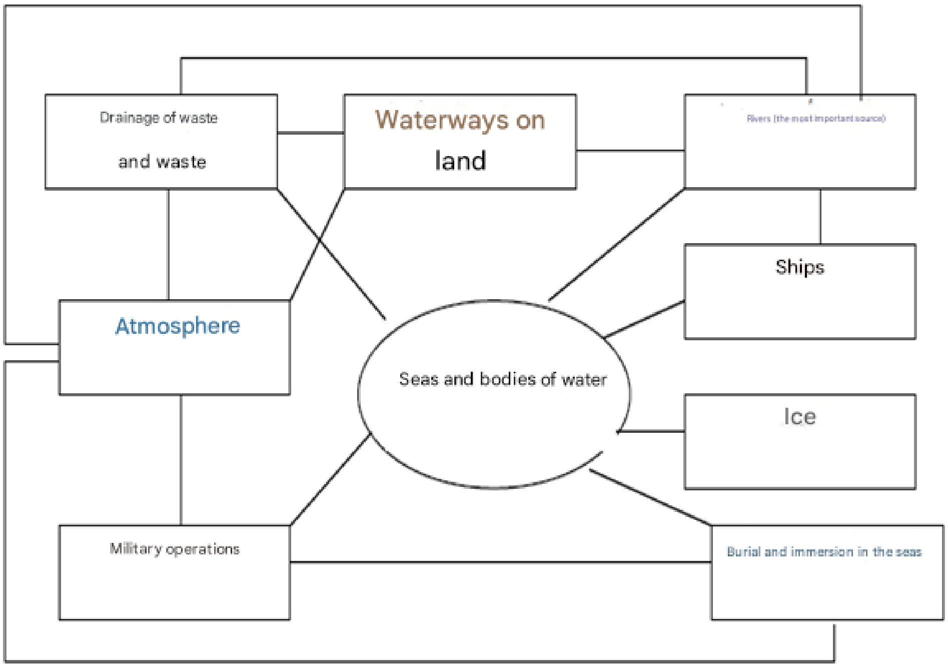

Figure (1): Ways pollutants reach the seas

Table (1): The most important pollutants in industrial wastewater

Pollutants	Its importance
suspended matter	It causes increased sludge deposits and anaerobic conditions in the water when discharged, such as nitrogen and phosphate, and leads to the growth of undesirable aquatic organisms
Pollutants of utmost concern	Carcinogenic and highly toxic organic and inorganic compounds
Membership is difficult to decompose.	Materials that have the ability to resist conventional treatment methods such as industrial detergents, phenols.
heavy metals	Heavy metals are products of various industrial processes.
Dissolved inorganic salts	Sodium, calcium, and sulfate salts

To assess the impact of pollutants on aquatic ecosystems, several characteristics must be determined, including:
1. The concentration of pollutants.
2. The persistence of pollutants within the environmental matrix.
3. The origins of pollution generation (including volume, quality, and consumption patterns).
4. The tendency of pollutants to bioaccumulate and concentrate within different systems or aquatic organisms.

5. The degree of toxicity and the potential for the pollutant to undergo chemical transformation, which may lead to increased levels of toxicity, thus intensifying the challenges and complexities associated with chemical pollution [7].

Factors that depend on the type and quantity of pollutants emitted by industrial activities are the most important:

1. The specific industrial sector.
2. The size of the facility, its age, and its maintenance protocols.
3. The operational framework of the facility and its production outputs.
4. The methodologies used in industrial processes.
5. The quality of the fuel and raw materials used.
6. The availability of different mechanisms aimed at mitigating pollutant emissions and their operational effectiveness [12].

Industrial wastewater has unique characteristics, as each sector exhibits its own types of pollution. The degree of pollution and the volume of industrial wastewater produced can vary significantly between different facilities, even when identical products are manufactured [7].

CLASSIFICATION OF POLLUTANTS PRESENT IN INDUSTRIAL WASTEWATER.

Pollutants in industrial wastewater that require continuous monitoring are classified based on treatment requirements:

1. Fats, oils and greases (FOG)
2. Adjustment of pH levels
3. Organic compounds
4. Inorganic compounds
5. Heavy metals, cyanides, arsenic, etc.
6. Ammonia, nitrates and nitrites.
7. Phosphorus-based compounds.
8. Sulphides.

It is important to recognize that the concentrations of pollutants discharged show variation across different regions and between individual manufacturing plants, as well as depending on the specific production methodologies used to create the same final product, resulting in the generation of a diverse spectrum of pollutants. Furthermore, it is noted that pollution levels are relatively lower for some industries, such as pharmaceuticals, textiles and battery manufacturing, compared to those observed in the Mediterranean region.

TOXIC EFFECTS OF INDUSTRIAL WASTEWATER

The rapid industrialization phenomenon that has occurred during the past few decades has significantly increased the number of pollutants present in the environment. Inadequate treatment of some hazardous industrial wastes discharged into aquatic ecosystems has led to toxic effects on various forms of life, both directly and indirectly. Heavy metals constitute a major class of water pollutants that exhibit persistence and resistance to biodegradation in natural environments. Bioaccumulation of certain toxic heavy metals within aquatic organisms can lead to adverse health effects on other animals and ultimately on humans across the food web. These substances may lead to malformations, carcinogenic effects, oxidative stress, organ dysfunction, neurological impairment, and growth and developmental impairment. Other prevalent chemical pollutants emitted from industrial activities are phenolic compounds. These substances exhibit toxicity by disrupting normal microbial processes, thereby negatively impacting bioremediation approaches. In addition, it may lead to a range of physiological effects including loss of reflexes, excessive sweating, hypothermia, cyanosis, decreased respiratory function, and ultimately respiratory failure. The main components of effluents from the pulp and paper industry, including tannins, resins, and chlorinated organic compounds, have the potential to induce genotoxicity and mutagenicity. The predominant effluents produced by the pulp industry are lignin and its derivatives. These compounds exhibit poor biodegradability and may be transformed into toxic entities in all biological treatment processes, which may disrupt the hormonal balance in aquatic organisms. Reproductive impairment in fish may occur as a result Some important wood sterols, such as beta-sitosterol and stigmasterol, bind to estrogen receptors in these aquatic species. The incorporation of harmful components within the textile waste makes it highly toxic. The combination of chromium compounds and oil emulsions generates a colloidal entity that acts as a barrier, preventing the penetration of sunlight into aquatic environments, thereby reducing dissolved oxygen levels. Many textile manufacturing entities use chlorine-based organic dyes, which are linked to carcinogenic outcomes. As documented in a case study published in The Tribune on April 7, 2009, in an area adjacent to Bathinda, Punjab, India, farmers suffered from cancer due to scarcity of canal water, forcing them to use toxic effluents from industrial plants for irrigation purposes. The harmful effects of perfluorooctanoic acid (PFOA) were examined in CD-1 mice, revealing adverse effects on maternal health as well as on neonatal developmental stages. Maternal mortality was associated with increased liver weight, decreased weight gain throughout pregnancy, while newborns showed decreased postnatal survival (approximately within the first six weeks after birth), prolonged eye opening, decreased body mass, and impaired growth and developmental trajectories. Research involving non-human primates (particularly baboons) has demonstrated the effects of PFOS exposure. Reduced body weight, decreased triiodothyronine (T3) levels, increased liver mass, and decreased cholesterol and estradiol concentrations were observed. Hypersalinity has a significant impact on the microbial activities of organisms not acclimated to saline environments. Furthermore, hypersalinity can disrupt aerobic treatment approaches. Implementing effective treatment strategies for these hazardous pollutants before they are discharged into various aquatic ecosystems is essential to maintaining a healthy and clean environment [5].

INDUSTRIAL WASTEWATER TREATMENT METHODS

Industrial wastewater is subjected to treatment and elimination of pollutants through different and varied methodologies and mechanisms as necessary. Treatment methodologies are classified into separate or integrated physical, chemical and biological treatment methods [9].

PHYSICAL TREATMENT PROCESSES

Processes that rely on natural phenomena and physical forces. These methodologies represent the oldest methods used to treat wastewater, as they are rooted in humanity's earliest observations of the natural world. These methodologies include: filtration, mixing, sedimentation, flotation, filtration, and gas movement.

CHEMICAL TREATMENT PROCESSES

Processes that rely on initiating a chemical reaction to facilitate the removal of contaminants or converting them into substances that can be easily separated from wastewater. The most common chemical strategies in this field include:

Sedimentation, adsorption, and disinfection. Chemical precipitation is accomplished by generating a chemical precipitate. This precipitate typically contains components that have undergone reactions with the input chemicals, as well as additional components that may be captured during the sedimentation phase. Adsorption relies on attractive forces between entities, facilitating the removal of certain compounds by adhering to the surfaces of solid substrates.

BIOLOGICAL TREATMENT PROCESSES

These approaches rely on biological mechanisms to treat pollutants. These techniques are mostly used to manage organic materials, either in foam or dissolved state, that show biodegradability. The operating principle involves converting these materials into gaseous forms that are dispersed in the surrounding atmosphere or absorbed into the biological cell matrix (sludge), which can be subsequently disposed of through sedimentation. Furthermore, biological treatment processes are useful in removing nutrients, especially nitrogen and phosphorus. Wastewater is often amenable to biological treatment, provided that appropriate environmental standards are maintained [9].

Table (2): Main pollutants of industrial effluents from different sectors along with their corresponding treatment methodologies [7].

Industry	Most common pollutants in industrial wastewater	Suggested treatment methods
Power Plants Commercial	Greases pH-TSS-Cu-Fe-Total Solids Chromium Iron Zinc	Lime precipitation -Separation of oils and greases -Adjustment (adjustment of pH) Filtration
Pesticide industry	BOD5-pH-TSS-CN-Pb-COD Organic pesticides	Use of activated carbon for desorption Desorption by redox -Extraction -Chemical oxidation followed by Steam stripping or adsorption by activated carbon -Chemical precipitation By carbides (pH adjustment)
Rubber industry	Oils and Greases BOD5-Cr-TSS-pH-Zn-COD-Pb	-Separation of oils and greases -Adjustment of pH -Separation of solids -Biological treatment followed by filtration and adsorption with activated carbon -Separation of solids by coagulation and chemical clarification -With sedimentation or by flotation
The copper industry	Oils and Greases pH-Cu-Cr-TSS-NI-Pb-Zn-TTO	- Oil removal - Hexagonal chromium recovery - Physicochemical lime treatment - Filtration
Asbestos industry	pH Suspended Materials COD	The first treatment is to adjust the pH (modification) and then precipitation.
Dairy industry	Oils & Greases pH-TSS-COD-BOD5	-pH adjustment -physicochemical treatment -chemical treatment -filtration
Grain milling industry	pH-TSS-BOD5	-pH adjustment

		-Extraction -Different biological treatment methods
Oil and gas extraction industry	Oils and Greases Sulfates Cd-Hg - Toxic Compounds - COD	-Removal of solids -Separation of oils and greases -Physicochemical treatment (Sometimes) not always necessary
Explosives industry	pH-TSS-COD-BOD5- Oils and Greases-Heavy Metals	- Oil and grease removal - Evaporation, clarification and sedimentation to remove heavy metals - pH adjustment - Biological treatment - Adsorption with activated carbon
Pharmaceutical industry	CN-TSS-PH-BOD5-NH3-COD Acetone - Toxic Organic Oils and Greases Phenols - Compounds	Physicochemical ammonia removal -Chemical treatment -Biological treatment -Activated carbon adsorption
carbon black manufacturing	Oils and greases Suspended materials Soluble salts - pH	Evaporation and sedimentation -Filtration before restoration -Skimming of oils and greases
Fertilizer industry	Fluoride BOD5-TSS-pH-COD Ammonia-Nitrate- Organic Carbon-Phosphorus	-Adjustment (pH adjustment) By lime and precipitation -Advanced biological treatment to remove organics Nitrogen and phosphorus -Ion exchange -Sterilization by chlorine Up to the point of ammonia decomposition
Solid Waste Treatment Centers	BOD-pH-TSS-TDS-Ag- As-Ba-Cd-CN-Co-Cu-Hg- Mo-Ni-Pb-Sb-Se-Sn-Ti-Zn Acetone-Phenols TTO -Toxic Organic Materials -Oils and Greases	- Removal of oils and greases - Removal of metals by -chemical precipitation - Special treatments with cyanide - Special treatments for toxic organic materials
Coal industry	pH-TSS Acidity - Alkalinity Mn-Fe Precipitable Solids	Fatas Madam - Clint Menf Braketable Solids
Fruit and vegetable reservation industry	Oils and Greases BOD5, pH, TSS	-Filtration (using filters - SCREENING - Chemical precipitation - Biological treatment - Chlorine and sterilization, especially if we want to reuse the water
Sugar industry	BOD5-pH-TC-TSS	-Sedimentation

		-Selection, filtration, sedimentation, and filtration, then reusing the water again -Biological treatment
Paint industry	Cr-Cu-Hg-Ni-Pb-Zn Organic Compounds Toxic Naphthalene Toluene	- Treatment before reuse, including coagulation, shaping and sedimentation - It can also be Biological treatment preceded by physicochemical treatment
Battery manufacturing	Oils and Greases pH-CN-Ag-TSS-Cd-Co-Cr-Cu-Fe-Hg-Mn-Ni-Pb-Zn-COD	-Removal of oils and greases -Adjustment -Removal of heavy metals -Filtration and reverse osmosis to remove ions
Metal forming industry	Oils and Greases TSS-pH-Cn-Cr-Cu-Pb-Ni-Ag-Zh-TTO	-Separation of oils and greases -Removal of cyanide -Reduction of hexavalent chromium to trivalent chromium and then its removal -Adjustment of pH -Physicochemical treatment
Leather tanning industry	BOD5-COD-Cr-TSS-pH Solonide - Oils & reases	- pH adjustment -Removing oils and grease -Selection, training and deposition -Biological treatment
phosphate manufacturing	Fluoride -TSS-pH Phosphorus	-Modification -Using lime to modify and remove fluoride and phosphorus.
Manufacture of inorganic chemicals	Oils and Greases pH, Suspended Materials As-Ag-Ba-Cr-Co-CN-Cd-Fe-Hg-NH3-Ni-COD-Zn-TTO Fluoride - Solenide	-Reducing chromium hexahydrate to chromium trihydrate to reduce chromium and cyanide -Alkaline precipitation -Filtration with filters -Adjusting pH
Gum industry	BOD5-COD-pH-TSS -Oils and Greases	-Separation of oils and greases -Compressed air circulating -Regular sludge -Removal of toxic organic matter
Electronic materials industry	pH-TSS-Ad-Cd-Cr-TTO Fluoride	-Modification -Chrome reduction -Coagulation and precipitation using lime. -Filtration
Soaps and detergents	Cod-BOD5-PH-TSS-ABS Oils and Greases	-Floating, selection, sifting and precipitation with calcium chloride -PH: adjusting acidity

CONCLUSION

Industrial effluents are a major contributor to marine pollution, which adversely affects both ecosystems and human health. Prompt and effective interventions are essential to mitigate this pollution and maintain the quality of marine water. Although health is a major concern, it cannot be denied that a growing economy also requires industrial growth. For overall social and economic growth and well-being, research into the development of such technologies that can reduce the use of freshwater by industrial sectors as well as into the development of efficient and effective water treatment methods is encouraged. New developments and continuous monitoring of strategies for implementing various programs and interventions related to industrial wastewater treatment are essential to ameliorate any toxic effects.

RECOMMENDATIONS

1- Formulate and implement robust treatment methodologies for industrial liquid wastes before they are released into marine environments.
2- Enhance the accuracy and comprehensiveness of environmental regulations and legal provisions aimed at protecting water resources.
3- Raise public awareness regarding the critical importance of maintaining the safety of seawater quality.
4- Make great efforts to reduce the impacts of economic and industrial activities by developing the necessary solutions to treat wastes facing the ecosystem.
5- Conduct more studies and research on the effects of pollution from environmental and health aspects

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