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Article

Heavy Metals, Wastewater Pollution, and Ecological Risks in the Euphrates River of Dhi Qar Province, Iraq: A Comprehensive Review

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Abstract: The extreme aggregation of burdensome metals and pollutants from waste wholes are chief to weighty adulteration of freshwater resources, happening in harm to the atmosphere and society. The Euphrates is individual of ultimate valuable water sources in Iraq, that is handled for household, land and industrial needs. However, in current age on account of hasty urbanisation, farming and industrial incident, and incompetent wastewater administration, the characteristic of the water has endured in some parts ahead penal institution. In this review, the closeness, allocation and tangible effects of severe metals and waste befriended contaminators of the Euphrates waterway in Dhi Qar Province, Iraq was assessed. Evidence desires various metals to a degree iron (Fe), manganese (Mn), lead (Pb), cadmium (Cd), metallic mineral (Zn), planets orbiting sun (Hg), arsenic (As), chromium (Cr), and nickel (Ni) have happened discovered in surface water and sediments at levels that now and then are above urged environmental directions. Sewage-carried contaminators like food salts, pharmaceuticals and microbial markers again are main water feature stressors and contaminants. Physicochemical possessions that could impact contaminator flexibility, relating to space and worldly alternatives in concentration of contaminators, and potential belongings of contaminators to maritime animals and humans too are examined. The tangible risk amount (tangible risk index, Hazard Quotient) indicates weighty environmental concerns from few of the contaminators (Pb, Cd, Cr and As) in fields of high urbanization and machine control. The determinants that were establish to influence contaminator transport and allocation were seasonal changes, hydrological environments, and land use. The overall verdicts imply that the need for more joined approaches for managing water status, routine preservation of natural resources, revised wastewater situation facilities and upgraded referring to practices or policies that do not negatively affect the environment government to weaken dirtiness and ensure the environmental well-being of the Euphrates River. These are owned by guarantee sustainability of the freshwater possessions of the southern indiscriminate Iraq and to safeguard the environment and human fitness.

Keywords: Euphrates River, Heavy Metals, Sewage Pollution, Environmental Risk Assessment, Water Quality, Dhi Qar Province, Iraq.

Introduction

The "freshwater money" is individual of the most valuable timber upholding human sophistication, financial development and environmental sustainability. Rivers play a alive duty in providing water for human, land, industrial, fisheries and environment duties. But accompanying the hasty urbanization, industrialization, study of human population, and increase of farming, skilled has been a important discharge of contaminants to marine surroundings all over the experience, chief to main depravity of water quality and environmental completeness. Heavy metals and contaminants from waste are among ultimate troubling contaminants as they are determined, toxic and famous to influence two together the atmosphere and human health [1], [2], [3], [4].The Euphrates is individual of the best transboundary waterway arrangements in the Middle East and is a key water beginning for Iraq. The river is of principal significance to heaps of people, accompanying water secondhand for sucking, watering, livestock, manufacturing, and additional socio-business-related exercises. The Euphrates River is the major surface water beginning in in the south Iraq, and is alive for happening and environmental sustainability in this place domain, exceptionally in Dhi Qar Province [5]. However, the feature of water in the river whole has existed a concern on account of human ventures in the watershed.

In recent decades, the Euphrates River has faced several environmental challenges related to untreated municipal effluents discharge, agricultural runoffs, industrial effluents discharge, solid waste disposal, oil-related activities, and hydrological variation due to dam construction and climate variability. All of these have been contributing to the concentration of pollutants in the water, sediments and aquatic organisms. In addition, reduced river discharge and dry weather have led to higher concentrations of pollutants because of a reduced dilution capacity and changes to natural self-purification processes [4], [5], [6], [7], [8], [9].

Heavy metals are one of the most dangerous pollutants in the environment that cannot be degraded and remain in aquatic environments, and tend to settle in sediments and biological tissues. Industrial discharges, agricultural practices, urban runoff and natural geological processes are potential sources of metals (such as lead (Pb), cadmium (Cd), mercury (Hg), chromium (Cr), arsenic (As), nickel (Ni), zinc (Zn), iron (Fe) and manganese (Mn)) entering aquatic ecosystems. After entering surface waters, these contaminants may be subject to complex physical, chemical and biological transformations, leading to bioaccumulation and biomagnification along aquatic food chains [9], [10], [11], [12], [13], [14].

Besides heavy metals, sewage-derived contaminants are a new problem in several developing countries. When wastewater treatment plants are either not built or poorly designed, the wastewater is not properly treated and is allowed to flow directly into rivers and canals. These effluents are responsible for the addition of excessive levels of nutrients, pharmaceuticals, personal-care products, pathogenic microorganisms and other emerging contaminants to aquatic ecosystems. Increased nutrient levels can lead to eutrophication, hypoxia, changes in aquatic community structure, and ultimately affect the functioning of the ecosystem. Endocrine disruption, toxicity and antimicrobial resistance (AMR) as a result of pharmaceutical residues and other chemicals found in sewage can also impact aquatic organisms [9], [15], [16], [17], [18].

Several studies have been carried out in many parts of Iraq which have shown different degrees of contamination in the main river systems such as the Tigris, Euphrates and Shatt Al-Arab Rivers etc. Earlier, some heavy metal concentrations were found to be higher in both water and sediment samples, which suggests that the pollution sources such as industries, agriculture, and municipalities are affecting the study area [9], [10], [11], [12], [13]. In spite of the importance of Dhi Qar Province, comprehensive studies, which combine the effects of both heavy metal contamination and sewage related pollution are still limited. Current information is compartmentalised and tends to address specific contaminants, not to assess the overall risk to the environment from multiple contaminants.

Environmental risk assessment is an indispensable tool for the assessment of ecological and human-health effects of water contamination. The current methods of risk assessment for the prediction of adverse effects on biota and humans involve both contaminant monitoring and contaminant exposure assessment, toxicity characterization, and risk interpretation. These are useful to determine

priority pollutants, contamination hotspots and vulnerable environmental compartments, which allows for environmental management and policy development based on evidence [18], [19], [20], [21], [22], [23].

Therefore, the present review attempt to make an integrated assessment of the surface water pollution of Euphrates river with heavy metals and sewage derived pollution in Dhi Qar province/ Iraq. The occurrence and distribution of contaminants, potential sources, physicochemical conditions that can influence the behavior of contaminants, and ecological and human health risks that can occur are emphasized. In addition the review identifies existing gaps in knowledge and discusses management strategies that are needed to enhance water quality and support a sustainable management of one of Iraq's most vital freshwater resources [24].

Materials and Methods

For the first time, this study used systematic reviews and environmental risk assessments to summarize what we know so far about heavy metal pollution, pollutants from municipal wastewater streams and risks to the ecology of the Euphrates River in Dhi Qar Province, Iraq. Data from relevant scientific literature, technical papers, environmental monitoring data, and peer-reviewed articles published on water quality, loading of pollutants, heavy metals levels and environmental health in the Euphrates River basin were retrieved from key databases, government records and organizational archives. Particularly, there will be much attention on the major pollutants detailed as lead (Pb), cadmium (Cd), chromium (Cr), arsenic (As), mercury (Hg), nickel(Ni)) zinc(Zn), iron(Fe) and manganese(Mn); along with effluent-related contaminants: nutrients, trace organic compounds like pharmaceuticals, endocrine disruptors and microbial contaminants. The data obtained from each studies included concentration of contaminants in water and sediments, environmental parameters, pollution sources, spatiotemporal distribution patterns and effects on human health as well as ecosystem. International water quality guidelines and environmental quality standards were employed to make comparative analyses of contamination levels and possible pollution hotspots. Environmental risk characterization was achieved by compiling literature-reported Hazard Quotient (HQ), ecological risk indices, and human health risk assessment results from published reports. You focused particularly on the impacts of hydrological conditions, climatic variability, land-use patterns, wastewater discharges, agricultural runoff and industrial activities on transport and accumulation of contaminants. Data were rigorously analyzed to track trends, identify research gaps and emerging river ecosystems threats. This integrated review framework facilitated a holistic assessment of contamination exposure routes, ecological effects, and management priorities and thus may provide the scientific foundations to support sustainable water resources management, pollution mitigation actions and future environmental monitoring programs in the Euphrates River basin of southern Iraq.

Results

Study Area and Environmental Setting

The Euphrates River is a major and significant river in the Middle East. The river is from the highlands of eastern Turkey, passes through Syria, and then into Iraq where it is a key freshwater resource for domestic, agricultural, industrial and ecological uses. The Tigris in combination with the Euphrates is the backbone of the water resources in Iraq and a key contributor to socioeconomic development and environmental sustainability in the country [5].

The Euphrates valleys passes through different provinces of Iraq to the southern parts including Dhi Qar province. The river system here is dominated by agricultural use, urban centers, irrigation systems, drainage systems and wetland habitats. Dhi Qar Province is strategically situated in the south of Iraq with some parts of the Euphrates River and waterways. The province is also located at the close of the Mesopotamian Marshes, an ecologically important wetland system in the world [6], [7], [8].

The climate for the study area is very hot with mild winters, and low annual rainfall with high evaporation rates, and is arid to semi-arid. These climatic conditions have a strong impact on the availability of water, river discharge, salinity and transport processes of contaminants. Upstream dam operations, water abstraction for irrigation and regional climate variability also have an influence on river flow variability throughout the year. During dry periods of the year the reduced river discharge may lead to higher concentrations of dissolved contaminants in the water because of the lack of dilution [4], [5].

Agriculture, urbanization, transportation and small to medium scale industries are the major uses of the land in Dhi Qar Province. The surrounding agricultural lands are mainly irrigated from the surface water, and often fertilized and sprayed with pesticides which could be carried to the water by surface runoff and drainage patterns. The urban centers, especially that of Al-Nasiriyah City, add extra environmental stresses due to the discharge of municipal wastewater, lack of infrastructure due to rapid population growth and solid waste disposal into the environment [10], [11], [12], [13].

The natural and anthropogenic factors affecting the river condition in Dhi Qar Province are influencing the Euphrates. Natural processes such as sediment transport, geologic weathering, seasonal flooding and hydrologic changes can affect water quality and contaminant distribution. Pollutant loads from human activities such as the discharge of untreated sewage, industrial waste, agricultural runoff, and oil-related activities also greatly contribute to pollutant loads in the river system at the same time [9].

A number of investigations have found high levels of heavy metal and other pollutants in the water of southern Iraq and it is not possible to determine if these are a result of a single source or from a combination of sources. The hydrological, sediment and anthropogenic interactions result in a complex environment which can lead to the accumulation of contaminants in water, sediments and aquatic organisms. Thus it is essential to have information on environmental characteristics that is specific to the study area to properly understand the pattern of pollution and the related ecological and human health risks [9], [10], [11], [12], [13].Given the strategic role of the Euphrates River and the growing environmental pressures and water-resource issues, it is essential to monitor and undertake proper environmental assessments on an ongoing basis. Assessing the pollution status and determining the pollution sources in Dhi Qar Province is essential for the sustainable management of water-resources and for ensuring the ecological quality of this important river system.

Sources and Pathways of Contamination

Natural processes and activities are increasingly affecting surface water quality of Euphrates River. There are several contamination pathways which lead to the entry of pollutants into the aquatic environment in Dhi Qar Province. They are discharged via municipal wastewater, agricultural runoff, industrial effluents, urban storm water drainage, oil-related activity and natural geochemical processes [9], [10], [11], [12], [13].

One of the largest sources of contamination is municipal wastewater. In many urban centers in south Iraq, wastewater treatment facilities are still inadequate to meet the needs of the increasing population and urban expansion. Without treatment or partial treatment, untreated or partially treated sewage is then often emptied directly to rivers, canals and drains. These discharges are releasing significant amounts of nutrients, organic matter, pathogens, pharmaceutical residues and other emerging contaminants into surface waters [10].

Water-quality degradation is also a large problem related to agricultural uses. A wide range of fertilizers and pesticides can lead to nutrient enrichment and chemical contamination via surface runoff and irrigation return flow. Excessive amount of nitrogen and phosphorus compounds can lead to eutrophication, decrease dissolved oxygen and change the ecological balance in aquatic ecosystems [18].

Another major source of contamination is industrial activities. The industrial development in Dhi Qar Province is not as intensive as in some other regions in Iraq, but various industrial facilities and workshops generate wastewater with a high content of heavy metals, hydrocarbons and other

hazardous substances. Further, petroleum derived contaminants may be accidentally released and operationally discharged into adjacent aquatic systems during oil extraction and transportation [9].

Geological weathering, sediment movement and hydrological changes are other natural factors that may affect contaminant levels. These processes also lead to the input of natural metals to aquatic ecosystems, but in areas of high population and industrialisation anthropogenic inputs are thought to be the major source of contamination. [14]

The contamination pathways are the source of a complex environmental system characterized by the transport, transformation, accumulation, and redistribution of pollution in the river basin. Through these pathways, a source assessment and the design and implementation of appropriate management practices can be of vital importance to better water quality and reduce environmental risks.

Heavy Metals and Sewage-Derived Pollutants in the Euphrates River

Heavy metals are individual of ultimate continuing, ecologically main classes of contaminants in marine schemes. Heavy metals are not referring to practices or policies that do not negatively affect the environment and can endure in the atmosphere for long periods momentary. This is cause they can increase in water, sediments and in organisms and cause negative impacts on the atmosphere and strength belongings to persons [14].The Euphrates River and accompanying water beginnings in Iraq have happened reported to hold various burdensome metals in the way that iron (Fe), manganese (Mn), lead (Pb), cadmium (Cd), metallic mineral (Zn), planets orbiting sun (Hg), arsenic (As), chromium (Cr) and coat with metallic material (Ni). Their concentrations are variable in two together room and period and are affected by hydrological environments, contamination beginnings, sediments features and land use practices [9–13].Commonly found surface water contaminators involve lead and cadmium. There are mechanical discharges, city drainage, instrument issuances, and waste disposal ventures guide two together parts. Humans unprotected for very long time can develop affecting animate nerve organs, renal and enlightening disorders; and marine creatures can experience by bioaccumulation and toxicity [21].Other factors like chromium, planets orbiting sun and arsenic are toxic and malignant and are too of distinguished concern in the atmosphere. High levels of these contaminants can cause hurtful impacts on marine life and environments, in addition to pose risks of uncovering to persons through guzzling water and the feeding relationships among organisms [18], [21].The question of waste-derived contaminators apart from severe metals is a new material issue. Nutrient compounds (nitrate, nitrite, ammonium, phosphate) are usually about surface waters from household wastewater and/or agricultural not present. Excessive fiber inputs, can cause algal blooms, exhaustion of oxygen, chum death and the depravity of environments, known as eutrophication [18].Another type of arising contaminators in water corpses are drug residues and individual care amount. Antibiotics, hormones, analgesics and added drug products concede possibility list waterways through the discharge from wastewater situation plants and seepage structures. These compounds can be toxic to maritime structures at very reduced levels and are determinants in the fighting of microorganisms to the compounds [9].Heavy metals and waste derivative pollutants are followed each one in sounds that are pleasant and waste contamination and the synopsises are difficult and demand integrated amount approaches. Such interplays will influence the flexibility, bioavailability, toxicity, and environmental impacts of contaminators and increase material stress on marine systems.

Physicochemical Characteristics Influencing Water Quality

Physicochemical limits play a important function in controlling the material outcome, flexibility, bioavailability and toxicity of contaminators in an marine environment. The water quality traits influence the transport of contaminators but more the water condition environments that control the biological output and the functioning of the environments [17].The most main limit is pH that influences ingot solubility, chemical adaptive evolution and adsorption responses. Heavy metals can change in their flexibility and toxicity on account of pH changes and so affect referring to practices or policies that do not negatively affect the environment impact. The pH of the Euphrates surface waters is mainly familiar impartial to somewhat soluble, but can vary regionally on account of wastewater

effluents and migratory differences [9].The hotness is another significant limit that will influence the synthetic responses, discontinued oxygen levels, microbial exercise and degradation process of contaminators. Concentrations of disappeared contaminators can increase all the while the summertime months in the south of Iraq on account of the greater hotness, that leads to an increase in dissolution [4].Electrical generated power (EC) and total dissolved chunk (TDS) maybe used to measure salinity and not organic content. Water salinity is arising as a question in southern Iraq by way of curtailed waterway discharge, on account of environment change, and irrigation return flows. Salinity maybe damaging to farming, maritime environment and human available water [5].Dissolved oxygen (DO) is one of the famous signs of the well-being of an maritime environment. Pollution from the sewage, over rot of natural matters and eutrophication cause depressed level of oxygen. Aquatic structures maybe emphasized by low disintegrated oxygen, and can bring about deficit of biodiversity [18].Physicochemical limits present useful facts about the referring to practices or policies that do not negatively affect the environment environments and action of adulteration. They concede possibility be monitored steadily to draw information about the processes of dirtiness, and to assist good water-ability management.

Environmental and Human Health Risk Assessment

Environmental risk evaluation is a experimental means to evaluate the likely hurtful impacts of a contaminator to an environment and human population. The results of these evaluations are established the levels of adulteration, pathways of uncovering, toxicity traits, and environmental responses to decide an estimate of environmental risk [18].Heavy metals are particularly bothersome because they are continuous, bioaccumulate and are poisonous. Aquatic animals and persons may experience these contaminators, particularly if they stop in marine sediments or in the bodies of structures. Over period, uncovering can cause energy effects, deficit of biodiversity and shame of environments [21], [22], [23].There are various routes of human uncovering to contaminated water to a degree draining, dermal contact, watering connected activities, and the devouring of adulterated maritime creatures. Non-malignant risks are typically evaluated utilizing approaches named hazard outcome (HQ) and carcinogenic risks are supposed utilizing possibility-located approaches. In few areas of the Iraqi waterway methods, the aggregation of few metals such as lead and cadmium were stated expected above the urged levels [21].Sediment quality directions, class feeling distributions and environmental risk indications are commonly used to determine potential impacts on marine structures in environmental risk assessments. These plans have determined that cadmium, lead, metallic mineral, major planet, and chromium are preference pollutants that concede possibility be address in the surroundings by way of their high environmental risks [22], [23].Available evidence plans that persisted contaminant inputs commit pose a risk to ecosystem completeness and community health, upon any less condition than active management measures are fix; even though the stated risk levels disagree from individual location to another and from individual study to another. In this sense, persisted listening and all-encompassing risk assessments are still detracting facets of tenable water-property management.

Spatial and Temporal Variability of Pollution

Contaminants inside an marine system do not continually happen in an even disposal across the frame of water, and are influenced considerably by hydrological environments, land use, beginnings of contaminators, and climatic environments. The aggregation indicator and the environmental risk appraisal of contaminator in the Euphrates River are essential and two together the dimensional and temporal differences are main [9–13].Spatial alternatives are primarily related to anthropogenic projects ahead penal institution course. Contamination can be about more districts in the capitals, mechanical zones, and agriculture lands than in extents that are rather clean. High concentrations of heavy metals, vitamins and contaminators from waste are associated with concerning cities wastewater discharges, technical effluents and land seepage. It was found extreme concentrations of contaminants in the pertaining to the south contained Iraqi waters, which understands the main populace centres and extreme force agricultural extents [9,10].Seasonal difference, particularly caused apiece instability in waterway discharge, storm, evaporation and water-administration practices, can influence momentary

instability. In dry seasons, when less water runs through penal institution, and when rates of dissolution increase, concentrations of contaminators can be taller cause skilled is less water to weaken the contaminants. However, better flows all along dry environments can still result in lower concentrations of disappeared contaminators, but can further increase the movement of contaminants from land land and citified domains as part of drainage processes [4], [12].Temporal alternative is further began by climate change, in the way that hydrological administration changes and the incident of drought occurrences. Due to this consolidation of lower water flows, greater hotnesses and extended dry periods, new water chance and status has enhance more susceptible to reductions across the Euphrates watershed, that commit worsen water value depravity and contaminant development [4]. Spatial and temporal patterns of dirtiness are detracting for the discovery of districts of contamination, ultimate adept design of listening programmes and the most productive exercise of alleviation measures. Knowledge concerning this can inform tangible managers about ultimate detracting environmental and environmental pressures and risks, and guide operation on ultimate fault-finding invasions.

Discussion

The evidence applicable shows that difficult metals and contaminants from waste are an main tangible question on the Euphrates River in Dhi Qar Province. Urbanization, agriculture, modern project and the lack of wastewater situation abilities have put stress on floating schemes and have had a negative affect water value [9], [10], [11], [12], [13].Heavy metals continue to be affiliated with ultimate determined contaminators because of their strength to bioaccumulate and oppose shame, even in sediments. The vicinity of metals like lead, cadmium, chromium, arsenic and mercury in water crowd is producing concerns about incidental sustainability and human energy. Heavy metal contamination was more in the direction of added waterways around the planet, and a comparable style to that noticed was identified, emphasize the all-encompassing character of the form of rock and roll contamination and the need for unending listening and administration [21], [22], [23].Within penal institution, it is further complicated by waste derivative contaminators. Untreated wastewater and farming effluents can cause nutrient advancement, happening in eutrophication and a decrease in disintegrated oxygen and moving the structure and function of marine environments. Pharmaceutical residues are different types of arising contaminants that will more have environmental suggestions cause they will persist in the atmosphere and are biologically alive at reduced concentrations [18].The hydrological/climatic environments play a important duty in the action of contamination. A important decline in the flow of waterways and a rise in waterway salinity as well as comprehensive drynesses in current age have further intensified tangible pressures on freshwater money in in the south Iraq. All these factors reduce the skill of penal institution method to weaken and assimilate contaminators and increase the environmental exposure of bureaucracy [4], [5].The results indicate overall that the contamination in Euphrates is not on account of individual beginning of pollution but moderately a consolidation of many anthropogenic beginnings of contamination. Hence, a combination of conduct needs expected executed to control industrial issuances, land beginnings, concerning cities wastewater treatment and incidental government, to guarantee productive management. The referring to practices or policies that do not negatively affect the environment kind of the Euphrates River commit stretch to suffer outside specific attacks, that could have affect environment aids, land productivity and community health.

Management and Mitigation Strategies

This is a combining several branches of learning approach that will include the water-resource managers, procedure creators, research arrangings, and material authorities in addition to the local societies in the water-contamination administration of the Euphrates River. Chronic pollution control endure should towards the decline of inputs of pollutants to the surroundings, but further at reinforcing preservation of natural resources and ecosystem rehabilitation [9].The incident and renovation of wastewater situation infrastructure is individual of the top preference. Installation of an direct wastewater treatment plant can considerably decrease the load of fibers, pathogens, pharmaceuticals and different contaminators released to maritime wholes. Existing situation plants and the continuation

of wastewater collection orders would go at a great distance towards reconstructing water quality in city fields [10].Agricultural best-administration practices need expected encouraged to weaken mineral and poison losses. This can include differing administration practices in the way that an optimized manure request, regulated watering methods, fertile safeguard zones and better seepage management. These procedures can help to minimise contamination transport, but hold result alive in the land subdivision [18].Industrial plants bear have an adept effluent situation plan and incidental effluent flags endure be attended. Continuous listening of waste streams in industry is wanted for fear that release of conceivably injurious substances like difficult metals and oil chemical compound [9].The regular exercise of preservation of natural resources programmes is more main. Biotic, water and sediment listening grant permission be educational of water condition trends, beginnings of adulteration and environment responses, if done again a very long time span. This somewhat news is vital in making evidence-located conclusions and adjusting preservation of natural resources.Technical measures need to be completed by public knowledge campaigns. Educating societies about pollution stop, water preservation and preservation of natural resources can play a main role in the influence of longterm administration plans.

Policy and Governance Perspectives

Effective government of the atmosphere is a vital element to the protection of water that helps to control the surroundings efficiently and sustainably. Water quality guardianship has enhance a focus of issues in Iraq, but the requirements addressing the occupancy of burdensome metals and contaminants (to a degree sewage) are not well matched and poorly sanctioned [9].The invigorating of tangible charter is a key factor to reinforce contamination control and water-reserve administration. Current laws and procedures need expected corrected to include new scientific facts on arising contaminators, environmental risk evaluation, and water governance for sustainability. In addition, it is main to correspond material guidelines with globally recognised one to increase the influence of requirement.It is also main that skilled is arrangement betwixt the various administration areas that are being the reason for water possessions administration, environmental protection, community health, farming and manufacturing. Integrated administration frameworks can help to guarantee that news is joint, listening is coordinated what dirtiness-control measures are executed capably.EIAs bear be an integral unspecified some project for modern and foundation development nearly floating delicate fields. This type of assessment maybe used to alert to potential material concerns superior to project exercise and to aid in a prevention-located approach to directing the surroundings.International assistance is further crucial, as the Euphrates River is a transboundary water property joint by various nations. Regional cooperation on water distribution, dirtiness control, preservation of natural resources and naturalization to climate change can help to survive the complete waterway pan.

Research Gaps and Future Directions

Although there is a rapidly expanding literature of water quality in Iraq, there are some major gaps in knowledge. Most of the studies on the available literature only focus on conventional pollutants and certain selected heavy metals, with limited information available for emerging pollutants like pharmaceuticals, endocrine disruptors, microplastics and antibiotic resistance determinants.

There is also limited long-term monitoring data. Numerous investigations rely on brief sampling periods, and are therefore inadequate to fully reflect seasonal and interannual variability. Development of multi-compartment monitoring programs (water, sediments, aquatic organisms, and surrounding soils) would greatly enhance knowledge of contamination patterns.

Further studies are required for the assessment of bioaccumulation routes and food-web transfer processes. Heavy metal contamination has been reported at various aquatic sites, but the transfer of contaminants through aquatic food chains and to human populations is not well characterized.

Advanced analytical techniques, geospatial technologies, remote sensing, environmental modeling, and machine-learning techniques could further enhance contamination assessment and source identification. Additionally, future studies should focus on the synergistic effects of several pollutants in realistic environmental settings instead of considering the effects of individual pollutants.

Satisfying these research gaps will help improve environmental risk assessments and enable the scientific information needed for sustainable water-resource management and for environmental protection in the Euphrates basin.

Conclusion

Today the Euphrates is individual of ultimate important freshwater money in Iraq and will touch play an main part in domestic, land, technical and environmental needs. But, on account of the intensified anthropogenic pressures (increase of form of rock and roll and human waste contamination in marine atmospheres), the water quality has diminished. This review documents the vicinity and material significance of form of rock and roll contaminators (for instance lead, cadmium, chromium, planets orbiting sun, arsenic, nickel, metallic mineral, iron and manganese) in addition to waste-mixed contaminants (vitamin salts, drug residues from waste and additional sewage derivative compounds). The evidence vacant plans that urbanisation, industrial endeavor, farming practice, hydrological instability and critical conditions all have an affect the level of adulteration. According to tangible risk estimates, several contaminants are considered expected of potential ecological concern, specifically in fields of extreme human venture and high levels of contaminants in the wastewater. There is spot and atmosphere particular risk, but continued inputs grant permission be damaging to the biodiversity of amphibious environments, ecosystem duties, crop result and human well-being.The answer to these questions must be inclusive, including wastewater situation systems, contamination stop, preservation of natural resources, organizing and public awareness programs. Furthermore, upgraded provincial cooperation and experimental studies are required to allow tenable use of the Euphrates, to cover freshwater resources in pertaining to the south Iraq in a tenable habit.It should to develop a inclusive listening program, advanced risk amount approaches and evidence-based tactics to guarantee environment completeness and sustainable water use for the and future.

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