

Impact of Industrial Waste on Natural Resources: A Review in the Context of Bangladesh

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Abstract

Although the industrial sector contributes significantly to Bangladesh's economic growth and development, unplanned rapid industrialization is having a detrimental impact on natural resources. Since industrial waste has become a major concern, this study reviewed previously published research papers to highlight the detrimental effects of industrial waste on natural resources. This review observed industrial waste have a substantial impact on natural resources, causing contamination of the air, water, and soil, alongside disruption of aquatic and forest ecology. Therefore, effective policy enforcement is expected to ensure that industrialization is sustainable, both in terms of mitigating environmental pollution and promoting more environmentally friendly industries. Bangladesh's long-term sustainability and prosperity necessitate industrialization, but it should be done in an environmentally sustainable manner.



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Acronym/Abbreviation

EIA	Environmental Impact Assessment	TLV	Threshold Limit Value
EIV	Environmental Impact Value	EPA	Environmental Protection Agency
NAAQS	National Ambient Air Quality Standards	DoE	Department of Environment
USNAAQS	United States National Ambient Air Quality Standards	SPM	Suspended Particulate Matter
BSTI	Bangladesh Standards and Testing Institution	TDS	Total Dissolved Solids
US EPA	United States Environmental Protection Agency	TSS	Total Suspended Solids
WHO	World Health Organization	DO	Dissolved Oxygen
		EC	Electrical Conductivity
		EQS	Environmental Quality Standard
		COD	Chemical Oxygen Demand
		BOD	Biochemical Oxygen Demand
		LCA	Life Cycle Assessment

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ETP	Effluent Treatment Plant	PLI	Pollution Load Index
DEPZ	Dhaka Export Processing Zone	PM _{2.5}	Particulate with a diameter of 2.5 microns or less
TR	Target Cancer Risk	PM ₁₀	Particulate with a diameter of 10 microns or less
EDI	Estimated Daily Intake		
ERI	Ecological Risk Index		

Introduction

Bangladesh is a mainly agrarian nation, with people relying on agriculture for food, fuel, fiber, raw materials, and other necessities. Bangladesh's favorable climatic conditions and abundance of natural resources have made this sector a promising source for employment, poverty reduction, and food security. Along with Agriculture, Bangladesh

has prioritized the industrial and service sectors to accelerate economic growth. Bangladesh's favorable policies and cheap labor attracted foreign investment in industry sector. As an output, the economy is expanding very fast, and rapid industrialization is taking place. (Figure 1) shows that industries have expanded all over the country.

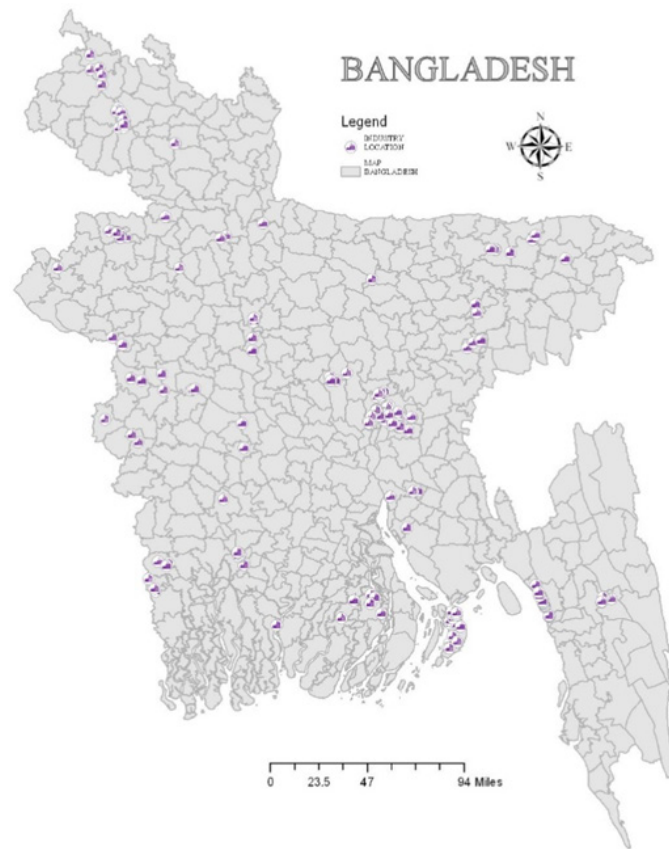


Fig. 1: Location of industries in Bangladesh¹

Bangladesh is now one of the world's fastest developing economies, including one of the top five exporters of Ready Made Garments (RMG), textiles, and apparel sector, accounting for roughly 20% of total GDP.² In 2019, the Industry sector contributed to total GDP around 31.13%.² Manufacturing sector

is the major contributor to the GDP of Bangladesh (Figure 2). Bangladesh Economic growth improves as the industry sector employs a larger share of employment, providing for almost 21.32% of overall employment in 2019.³

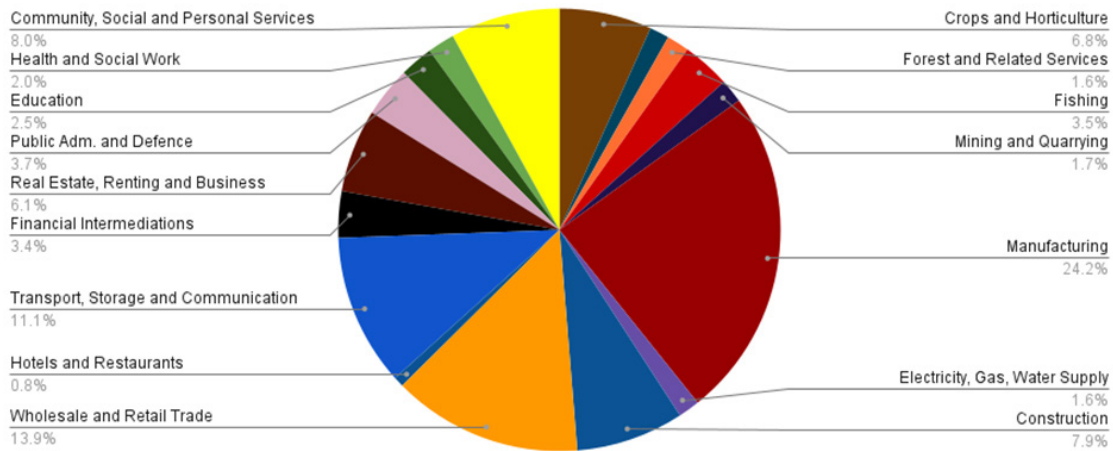


Fig. 2: Sectoral contribution to GDP⁴

Though industrial sector has a huge contribution to economic development but unplanned rapid industrialization is bringing out adverse impacts on natural resources. Bangladesh loses 8000 ha. of farmland annually due to rapid urbanization, industrialization, unanticipated rural housing, and infrastructure development.⁵ Industrialization is one of the main reasons for environmental pollution⁶ and industrial pollution is wreaking havoc on the environment, destroying natural resources. Natural and anthropogenic practices are increasingly depleting resources, which is alarming. Agriculture, fisheries and forestry contributed 30.49% of GDP in 1990, but that share has dropped to 12.68% in 2019.⁷ According to World Bank, "Forest area remained 30.72% of land area in 2016 and agricultural land stood at 36.9% of land area in 2018, CO₂ emission determined 4.56 metric tons per capita in 2016". Every year, Bangladesh loses over \$6.5 billion, around 3.4% of its GDP, due to environmental contamination and depletion in urban environments, with pollution accounting for 28% of all deaths, which is 16% of the global average.⁸ Bangladesh spotted 1st position among most polluted countries with a PM2.5 reading of 83.30 micrograms per cubic meter and Dhaka ranked 21st position among most polluted cities in 2019.⁹

Various industries are constantly increasing with planned or unplanned manner and adding pollutant concentration in the atmosphere. Chemicals emitted by various industries are listed in (Table 1). Untreated waste from tannery industries wreaks havoc on fisheries, forests, and wildlife.¹⁰ The tannery and

leather industries released the most dangerous substances into water, whereas the pulp and paper industries were also reported to be responsible for water pollution. Industrial pollution created challenges for fisheries sector by the pollution of water and marine lives in the coastal region are endangered.¹¹ Pollution of air, water, land caused mainly by pulp and paper, food, tannery and leather industry where food industry caused greater air pollution, and sugar, mill, oil factories contributed in pollutant emission in the air.¹² Hence, 81% of hazardous chemical emissions would end up in the air.¹² Artificial dyes like sulfur, azoic, indigoids, nitrates, acetic acid, enzymes, and soap containing heavy metalloids and compounds posed a significant danger to the natural environment and living organisms.¹³ Ecosystem and public health were found in threat due to heavy metals discharge.¹⁴ The exposure of hazardous metals hinted at the influential detrimental effect on the ecosystem, human health, aquatic ecotoxicity, and terrestrial ecotoxicity where Cr was found as a major soil contaminant and Pb, Zn possessed potentialities for groundwater contamination.¹⁵

In 2008, Asian Development Bank reported an inventory of Hazardous waste in Bangladesh.¹⁶ Every year, the textile dyeing industry generates around 113.72 tons of solid waste and 99.75 million cubic meters of liquid waste. Yearly, the tanning industry yearly generates around 26,250 tons of solid waste and 1.3 million cubic meters of liquid waste. Hospitals and clinics generate 12,271 tons of solid waste. Agriculture-related industries, such as

pesticide manufacturing, produce 277 tons of solid waste and 7.8 million cubic meters of liquid waste per year, while fertilizer manufacturing generates 357 tons of solid waste and 10.97 million cubic meters

of liquid waste per year. Oil refining generates 4 tons of solid trash per year and 0.61 million cubic meters of liquid waste per year.

Table 1: Chemicals regarding various industries¹⁶

Industry	Chemicals
Acid Handlers and Suppliers	Nitric acid, Sulfuric acid, Hydrochloric acid
Adhesive and Glue Makers	Methylethyl, Ketones, Toluene, Acetone
Bleaching Powder	Chlorine
Battery Manufacturer	Lead, Sulfuric acid
Chlor Alkali (Caustic Soda)	Chlorine, Mercury, Hydrogen gas
Fertilizer	Ammonia, Carbon monoxide, Phosphoric acid, Sulfuric acid
Paints and Varnishes	Solvents, Metallic oxides of Pb,Ti
Pesticides	Benzene, Toluene, Butane, Organophosphorus materials
Pharmaceutical	Organic chemicals
Industrial Chemicals	Sulfuric acid, Sodium Silicate
Plastics	PVC Solvents
Rayon Manufacture	Mercury, Chlorine
Synthetic Foam	Cyanides, Solvents
Vegetable oils, Ghee	Hydrogen, Toxic Dyes, Hazardous Waste
Textile, Dying and printing	
Clinic and Hospitals	
Ship breaking and Dismantling	
Petroleum Refinery	
E-waste	
Paper and Pulp	

The tannery industry's EIA report revealed a detrimental impact on physical and biological resources such as air quality, surface water quality, land quality, fisheries, aquatic biology, vegetative cover, biodiversity, and agriculture, concluding that soil and river water ambience is impaired, as well as a disrupted ecological equilibrium.¹⁷ Total EIV obtained negative along with adverse impact on physical resources (air, water, and soil) and ecological resources (fisheries, forestry).¹⁸ Physical and ecological resources were found adversely affected as their EIV obtained negative due to washing and dyeing industries.¹⁹ The EIA report of ship-breaking industries found a negative effect on abiotic and biotic factors which included soil quality, soil fertility, air quality, water quality, vegetation coverage, animal life, forest, and biodiversity.²⁰ Limitation of resources, absence of interagency coordination, lack of monitored regulation determined as constraints of administration, resulting in continued pollution.²¹

Since industrial disposal has become a matter of concern, this study brings together previously published papers to highlight detrimental effect of industrial waste on natural resources. The purpose of this study is to discuss how industrial wastes are affecting physical and ecological resources of Bangladesh. This study contributes to the existing literature by analyzing the findings of numerous evidence on the effects of industrial waste on air, water, soil, aquatic, and forest resources. This may help the policymakers to take adequate measures to protect natural resources by minimizing industrial pollution.

Impact on Physical Resources Pollution of Air

In Bangladesh, Industrial exposures were identified as major causes of air pollution.^{22,23} The brick kiln industry, cement, steel, rice mill, glass factory regarded as major influential contributors in

air quality deterioration.²⁴ Also, agro-based industries like paper, pulp, sugar, textile, tanneries, pharmaceuticals, oil refineries, fertilizers, and chemical factories were found responsible for the vulnerable quality of air.²⁵ Industries were marked as major pollution sources²⁶ and air contamination was exacerbated by factory residuals, smoke emissions, and poor solid waste disposal.²⁵ EIA report of tanneries in Dhaka revealed negative effects on air quality¹⁷ that leads to air pollution.¹⁰ EIA report of textile dyeing factories in Gazipur revealed the detrimental impact on air meteorology and air quality.^{19,27} Even at sugar mill localities, PM₁₀, NO_x, and SO₂ were noticed.²⁸ In Kushtia sugar mills, Particulate Matter (PM10) found high concentration contributor, and API hinted health issues due to intensive air pollution.²⁸ A study conducted in greater Dhaka city found, PM_{2.5}, PM₁₀, SO₂, NO₂, and CO maximum during winter and minimum in monsoon.²⁶ Particulate Matter concentration showed major threat to existing habitants as they surpassed level of Bangladesh NAAQS and USNAAQS standards.²⁶ In dry season, the brick kiln has been regarded as a critical contributor to air pollution in Dhaka.²⁹ Brickfields Particulate Matter was identified as a significant pollutant in Savar, raising concerns in the surrounding areas of the brickfield.³⁰ The brick kiln was discovered to be the primary source of sulfur dioxide, carbon monoxide, hydrocarbon pollutants,³⁰ and black carbon particle composition.²³ Exposures of Sulfur dioxide, Carbon dioxide, black carbon, and Carbon monoxide concentration found raising at an alarming rate due to brick kiln clusters.³¹ The waste of garment factories responsible for odor problems.³² Petroleum refineries emit harmful and toxic air pollutants such benzene, xylene, toluene, and ethylbenzene.³³ The value of SPM crossed the TLV consulted by WHO, EPA, and DoE.³⁴ To control air emissions, plans and measures should be established that is essential to include government regulations and action plan.²⁹ Industrial policies such as a comprehensive land use strategy, cluster management, technological and emission standard strategies, maintenance and management, appropriate plant for air pollution mitigation, and regulating importation for coal quality control must all be implemented.²⁴ Industries like tannery, battery, pharmaceutical, tobacco should be relocated with proper disposal system of discharges²² and for textile factories, air quality index were suggested.^{19,27} ETP installation, legislation enforcement regarding

environment, waste management, training program for workers, relocation of industries out of city determined as requisites.³²

Pollution of Water

In Bangladesh, Industrial discharges are one of the major sources of water pollution.³⁵ Around 90% of water is utilized by energy sectors and humans whereas divergence of water from underground and surface water sources is higher by the industries compared to their real amount of consumption.³⁶ Surface water has been heavily polluted as a result of the rise in industries.³⁷ In Bangladesh, Heavy metal translocation increased the concentration in agricultural irrigation water of industrial zone.^{38,39} Increased in concentration of EC, Cd, Pb, and Ni become a significant threat.^{6,37} Research conducted in Tongi canal found, irrigation water became problematic as concentration of HCO₃, SO₄, PO₄, K contents surpassed the recommended limit.⁶ In Narai canal and Balu river, TDS, DO, and NH₄⁺ were in extreme condition and which indicated that water became unsuitable for human, aquaculture, and irrigation practices.⁴⁰ The estimated EC showed medium to high salinity due to heavy metalloids in the Karatoa river water sources, while the measured DO indicated stressed aquatic life, and water bodies were unsuitable and hard graded.⁴¹ Heavy metals like arsenic, which is rising at an unexpected pace in underground water due to elevated amounts of Fe, Cr, Pb, and Ni are present in contaminated water sources.⁴² Tannery industries have raised concerns over environmental sustainability after it was discovered that they have a detrimental impact on the atmosphere.¹⁰ Mismanagement of waste from tanning plants, inferior technology, and insufficient disposal systems exacerbated quality of the water, leading to disrupted aquatic biology and surface water contamination, higher levels of S²⁻, Fe, NH₃, COD, and EC indicate real problem because they pose a significant danger to the ecosystem and also overall pollution.⁴³ A study conducted in Madina tannery of Chittagong found EIV was negative regarding physiochemical factors like groundwater pollution, surface water contamination.¹⁰ Tannery effluents had a lower pH and DO but a high amount of BOD, Cl⁻, SO₄⁻, and Cr.⁴⁴ Textile dyeing has a detrimental impact on quality of surface water.^{19,45} Textile dyeing effluents contained higher pH, NO₂⁻ and NO₃⁻⁴⁴ and untreated textile discharges decreased the amount of DO,

depleted groundwater level with its contamination, adversely affected aquatic ecology and also led to climate change.⁴⁶ Waterbodies became badly polluted in Bangladesh because petroleum and petrochemical industries expanded near freshwater sources.³³ EIA report revealed influential detrimental impact of textile and dyeing industries waste on water.¹⁹ Physio-ecological and ecological resources were found disturbed.^{19,45} Most adverse impact found on state of surface water⁴⁵ while influential impact on surface water, groundwater, hydrology, aquatic biology, and fisheries.^{19,45} In Dhaka, Textile and tanning industry wastes had higher EC, TSS, TDS, and heavy metal levels.⁴⁴ Study conducted in 5 rivers of Bangladesh (Buriganga, Turag, Shitalakkha, Dhaleshawari, Brahmaputra) found that, quality of Surface water disrupted due to waste of textile factories as COD, BOD, SS, alkalinity, Cl, DO, TDS, EC were beyond EQS standard and thus it is hazardous to ecosystem and human body.⁴⁷ Printing and Dyeing factories require high volume of water for production purposes and conventional wastewater treatment plants caused water pollution by turning it to waste water.¹³ Pharmaceutical waste has affected aquatic life, microorganisms, and human body.⁴⁸ EC, TDS, chloride, metal and oil contents found higher in Sitakundo due to increased level of contamination in recycling and ship breaking industries of Bangladesh that EIV was not acceptable for sustainable environment.¹⁸ Significant issues arose due to industrial pollutants, including high pollution, low fertility, high infestation, dermal disease, and low yield.³⁷ Toxic metals are responsible for deterioration of source of agricultural irrigation water and thus enter to the food chain.⁴¹ Effective management of dumping site,⁴⁰ maintaining distance from water source,⁴⁰ installation of ETP,⁴⁰ rules and legislation by industry in case of disposal into the river,⁴⁰ appropriate water treatment,⁴¹ The DoE should ensure that sources of pollution are monitored, that effective initiatives are approved, and that environmental law is applied.⁶ To decrease water pollution proper monitoring, modern treatment procedures, modern water supply management, consciousness regarding safe water utilization and implementation of laws must be focused.⁴² In case of tannery industries, relocation of tannery industry out of city¹⁷ or particular industrial zone,¹⁰ construction of central sewage treatment plant¹⁷ or waste treatment,¹⁰ proper environmental management plan,^{10,17} ensuring safety to workers,^{17,18} minimizing

intensity of other pollution and hazards are pre requisite.¹⁷ For dyeing and printing industries waste treatment and legislation should be established.¹³ For ship breaking and recycling industries specific zones for ship processing, appropriate disposal of wastes, national polices, scientific research techniques, Safety for human and aquatic lives should be assured.¹⁸ To protect aquatic biology and minimizing water depletion and stress, discharge volume of wastes it is required to take several initiatives for textile industries.⁴⁶ Appropriate technologies,⁴⁶ cleaner production,⁴⁶ recycling of used water,⁴⁶ ETP installation,^{45,19} designed project plan for protecting fisheries,⁴⁵ worker's safety,^{19,45} training,⁴⁵ waste disposal and effluents treatment¹⁹ should be ensured.

Pollution of Soil

Factories are a significant contributor to the diversion of agricultural land as well as the decline in agricultural production,⁴⁹ The natural environment's equilibrium was broken after the growth of industries.⁵⁰ Food insecurity has been linked to industrialization as a factor restricting agricultural productivity.⁵¹ Industrial development has outpaced agricultural growth,⁵¹ and it generates heavy metalloids^{52,53} and solid waste,⁵⁴ and environmental deterioration.⁵⁵ Heavy metals released into the soil by factories pose a significant danger to the atmosphere, as soil toxicity and pollution result from rapid industrial activity.⁵⁶ Heavy metal deposition in farm soils is closely related to industrial wastewater used for irrigation.⁵⁷ Although the readymade garments industry contributed significantly to growth of nearby areas, the inadequate amenities and facilities exacerbated the problem.⁵⁰ The ascendant order of metallic concentration (Fe > Zn > Ni > Cr > Pb > Cu > Cd) was found in arable soil where Cd content in soil surpassed the allowable limit around industrial localities.³⁹ Soil quality, concentration of heavy metalloids, and chemical attributes were marked to change as industrial effluents caused adverse impacts on downstream zone of waste unload site in Gazipur.⁵⁸ Higher levels of sulfur, but lower levels of OM, N, and P as well as substantial amounts of Zn, Fe, Cu, Cd, and Pb, were found in Gazipur's industrial sector.⁵⁸ Located industrial sites were contaminated by heavy metalloids at a different level of parameter⁵³ that polluted agricultural resources.⁵² In agricultural soil near DEPZ, great proportion of As, Fe, Hg, Mn, Zn was observed in the dry

season and As, Fe, Mn, Zn, Hg determined in wet season.⁵⁵ During dry season, significant amount of heavy metalloids were detected in the Tejgaon industrial areas, indicating that untreated residuals organic toxins and containing hazardous heavy metalloids were contaminating the ecosystem.⁵⁹ An assessment study of soil quality near Barapukuria Coal Mining Industrial Zone revealed that, the production of iron pyrite and chalcopyrite during the coal mining process showed a negative effect on soil health, indicating a threat to the ecosystem and soil quality.⁶⁰ The soil of Barapukuria Coal Mining Industrial Zone contained relatively lower pH and nitrogen levels than Standard Value whereas concentration of K, Fe, OM, Cu exceeded the Standard Reference Value in terms of agriculture.⁶⁰ Cr, Ni, Pb Cu, Cd, and As were found in the nearness of industrial sites of Jhenaidah and kushtia districts, and the Cd content in agricultural soil surpassed the recommended level, indicating a moderate to very high Potential Ecological Risk.⁶¹ EDI value of Pb, Cr, As, Ni Cd, found higher, THQs values of Pb, Ni, As, Cu, Cd surpassed the threshold value and TR of As, Pb surpassed the US EPA threshold value in industrial localities of Tangail.⁶² Discharged wastes of multi industries (textile, dye, agrochemical, paint, and chemical) provided higher concentrations of Zn, Cu, Cr, and Pb to the soil, irrigation water, and As, Cr, Pb concentration was measured beyond recommended limit.⁶³ Geo-accumulation Index indicated, the presence of Zn and Pb degraded the soil moderately in Bhaluka industrial areas, with high levels of Zn, Cu, and Pb posing a hazard to surface soil quality and habitats.⁶⁴ Study conducted in Dhaka Aricha road found Cd levels in soil were elevated, resulting in higher Cd, Cr levels in vegetables also The Potential ERI showed that high concentration of Cd posed a danger to the surrounding environment, while the Transfer Factor of Cd, Pb expressed the possibility of risk occurrence since they are higher accumulators in leafy vegetables.⁶⁵ Cd, As, Cu, Pb, and Ni concentrations in 12 separate land use urban soils in Dhaka surpassed the Dutch Target Value, and Cr was found to be a contributory factor.⁶⁶ Contamination Factor values indicated Cd contamination in urban soils due to metallic contamination, while the PLI revealed soil health deterioration.⁶⁶ Uptake of heavy metalloids occurred by plants and enter to the food.⁵⁸ EIA report of Hazaribag revealed, the tannery industry has a detrimental impact on ecology (vegetative cover,

wildlife), and agriculture.⁶⁷ N, P, K was observed to be lower on rice plants that were planted on contaminated soil, indicating a significant negative effect on soil and plant growth.³⁷ Heavy metalloids are responsible for entering in ecosystem and deteriorate human health, wild and bio environment.⁵⁵ Industrial Pollution is a core problem of environment as improper industrial practices exist for many decades. Solid waste management is constrained due to absent of recycling, appropriate handling, and disposing, awareness, financial support, and appropriate technologies.⁵⁴ Careless waste unloading must be stopped, and waste handling with appropriate disposal policies must be ensured.⁵⁸ More focus should be paid to the use of caustic soda and sulfuric acid during the production process, as well as the use of a pretreatment facility and product recycling.³⁷ Rules and legislation, ETP installation, wastewater recycling, industrial modernization are prerequisites.⁵⁵ Furthermore, there must be emphasized on solid waste disposal, effective plan, and evaluation of effects on soil quality should be executed.⁶⁷ Industrial waste management should include monitoring carbon exposure, market-based reward governance, recycling, and green technology adaptation.²⁵

Impact on Ecological Resources

Disruption of Aquatic Ecology

Industrialization contributed significant Negative impact on aquatic animals because of heavy metals unloading.⁶⁸ One of the causes of worsening water quality, as well as negative impacts on sediments and aquatic fauna, has been described as industrialization.⁶⁹ Aquatic pollution has been linked to industrialization⁷⁰ where industrial discharges were found to be responsible for altering water chemistry⁷¹ and leading to wastewater accumulation in rivers.⁷² Owing to the lack of adequate treatment facilities, toxic wastes were identified⁷² as a source of pathogenic microbial contamination in the water sources of industrial localities, and the elevated rate of discharges signaled a serious threat to aquatic biology and ecosystems.⁷⁰ Study conducted in Kushtia Sugar Mill areas found the metals of effluents failed to match the Standard of DoE and ground water quality.⁷¹ High values of TDS, BOD, COD, Cl⁻, K⁺, Ca⁺, Mg⁺, SO₄⁻, PO₄⁻, NO₃⁻, and low level of DO indicated water pollution and hinted toxicity to aquatic life.⁷¹ The water quality of Bhairab river nearside of Noapara Industrial area is at the lowest

in the summer due to continuous pollution, and high amount of Fe and Mg have an adverse impact on aquatic life.⁷² The dyes and chemicals of textile industries contained Cu, Cr, Zn and they were responsible for increased level of BOD and disruption of photosynthesis and re oxygenation that an impact on aquatic species.⁷³ The raised concentrations of Pb, As, Cr, Cd harm ecosystem of Karnaphuli river.⁶⁹ The studied water bodies of Buriganga river found affected as water quality that examined not suitable for aquatic ecosystem.³⁵ Metals and chemicals from ship breaking industries had significant negative impact on marine ecosystem, fisheries.⁷⁴ Marine ecology consisting fish, mammals, plants, planktons, reptile, benthic invertebrates faced physical inconvenience, and ecology was affected due to heavy metals discharge from ship breaking industrial activities in Shitakunda.⁷⁵ Industrial toxic wastes have been listed as one of the sources of contamination in coastal region that could endanger aquatic species' survival.⁷⁶ Toxic metals (Cu, Cd, Hg, Cr, Ni, Pb, and U) in water channels of coastal areas, which have an impact on water quality, aquatic biodiversity, and seafood safety.⁷⁶ Industrialization influenced heavy metals toxicity in Rupsha river which resulted in As, Pb, Cd, Cu, Ni, Cr concentration at various ranges and calculated ERI expressed significant low level to moderate level of ecological risk.⁷⁷ The high EC, color, and odor of Bangshi river indicated deteriorated water quality, water that was deemed unsuitable for aquatic biology, and industrial practices linked to this crisis, posing threat to aquatic assets' sustainability.⁷⁸ Study performed in Bhaluka industrial area found Zn in wastewater which posed a hazard to aquaculture.⁷⁹ At the adjacent lake of industrial zone in Savar, COD was observed to be out of the standard range, and Cd, Co, Fe, Pb, Mn, and Hg were at above of the recommended level.⁸⁰ Full Chrome Leather were identified to be a greater contributor in aquatic pollution such as aquatic eco toxicity and aquatic acidification whereas Chrome Retanned Crust Leather found significant contributor in aquatic eutrophication.⁸ The total and dissolved concentrations of Ni, Cr, As, Cu, Cd, and Pb were detected in various ranges in Dhaka, indicating that unloaded wastewater from factories could degrade the aquatic ecosystem, and thus a wide variety of industries were remarked as a source of environmental pollution.⁸² Industrial effluents greatly increased the levels of metal content in estuarine water, resulting in a disrupted marine

habitat.⁸³ Concentrations of As, Zn, Pb, Cd, Ni, Cr, Cu in textile and tannery effluents were measured at various levels in Buriganga and Karnatoli river.⁸⁴ Values of chloride, TDS, Total hardness, alkalinity of Rupsha river was out of BSTI limit where Cr, Pb, Fe, Ni, Mn, Ag concentration exceeded the BSTI and WHO permissible limit as a result pollution of aquatic ecosystem lead to detrimental effects on the local environments.⁸⁵ EIA report of tanneries of hazaribag expressed negative impact on fisheries, aquatic biology as unloading of solid wastes caused adverse impact on aquatic biology and fisheries.¹⁷ Tanneries wastewater directly fell into the river, resulting adverse effects to the aquatic biology, and TSS, TDS, TS were also higher which hinted negative impact⁸⁶ that constraints photosynthesis of aquatic plants and planktons.⁸⁶ The establishment of scrapping facilities by ship-breaking industries found to be responsible to collapse of fisheries stocks as most of them located near fisheries areas.⁸⁷ Study conducted in khiru river found, Cd concentration of soil sediment and water exceeded the recommended limit and Zn, Cu, Cd, Pb, Mn, K, Na, As were assessed in different fish muscle.⁸⁸ Concentration of Fe, Cr, Pb, Cd found higher in water body of Balu river and pH, EC, appearance, color of water showed environmental risk.⁸⁹ Mismanagement of garments wastes in Naranganj was found responsible for affecting environment of shitalakkhya river.³² Effluents of tannery, pulp, fertilizer industries caused adverse impact on aquatic life where water resources declination were highest among the socio-economic hazards.⁹⁰ Cement industries were also responsible for negative effects on aquatic life and water resources.⁹⁰ The water quality of the Dhaleshwari River is deteriorating to a significant amount, and a major degradation in environmental quality might occur in a few years, posing a serious hazard to human and aquatic life.⁹¹ Proper steps need to be taken to save aquatic ecology. Conduction of EIA, Government support for technologies and facilities, wastewater treatment facilities and discharge treatment facilities need to be ensured.⁷⁰ Research activities, pretreatment facilities, laws and regulation, awareness program, technological development regarding environment need to be enforced.⁷¹ Waste water treatment and regulation, awareness regarding pollution and protection strategies need to be taken.⁷² ETP installation.^{73,81,88} Regulated monitoring of heavy metalloids discharge^{69,76} to preserve water

quality and effluent Management need to be ensured.⁶⁹ Priority on polluted water treatment, policy implementation, management strategies and awareness need to be raised.⁷⁸ LCA should be done for reducing environmental pollution.⁸¹ Treatment plants need to be adopted to maintain water quality.⁸⁴ Monitoring coastal area along with further studies on industrial impact to coastal water need to be executed.⁸⁵ Appropriate management of river with further investigation need to be ensured.⁸⁸ Proper management and precautions regarding water contamination for betterment of aquatic habitation.⁸⁸ River management and rehabilitation along with proper strategies, rules and regulation should be executed.⁸⁹

Disruption of Forest Ecology

Environmental pollution is exacerbated by industrial waste, which has a detrimental effect on the forest ecosystem. Commercial discharges have been reported as one of the leading causes of forest disruption and responsible for biological and environmental consequences such as biodiversity destruction, animal and plant extinction, and habitat depletion.⁹² The tanning, wood, and fertilizer industries' effluents all had an adverse effect on forest resources.⁹⁰ The shrimp farming industry may have a detrimental effect on the ecology of mangrove forests, and heavy pollution may alter the biogeochemistry of such areas.⁹³ Heavy metals have affected the Sundarban mangrove forest and environment, with high concentrations of metalloids (Fe, Zn and Pb) contained in macrobenthos, with Pb concentrations exceeding the WHO's recommended limit.⁹⁴ Still, significant concentrations of Cd and Fe were found in mudskippers and gastropods, implying that such metals were deposited in benthic fauna.⁹⁴ Meanwhile, the Sundarban mangrove forest's ecology and biodiversity was reported as endangered, with industrial pollution identified as a significant contributor.⁹⁵ The trace elements Fe, Cd, and Cr were found in higher concentrations in Sundarban sediments where Cd levels were moderate to severe.⁹⁶ High concentration of Cu, Cr, Ni, and As in the atmosphere have an eco-toxicological effect on living organisms.⁹⁶ Contaminants such as heavy metals, physiochemical properties, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl compounds (PCBs), organotin, oil, grease, asbestos had a detrimental

impact on forest resources due to shipbreaking industries.⁷⁴ Sustainable Management Plans, science studies, and conservation procedures must all be applied to conserve the forest.⁹³ Ecological restoration, legal action, awareness, monitoring, and management actions should be implemented.⁹⁵ In case of ship-breaking industries, Government policies, supervision, monitoring, scientific research methodology, separate locations must be executed.⁷⁴

Conclusion

From the literature survey, it is evident that natural resources are being substantially affected by Industrial waste that responsible for pollution of air, water, and soil along with disruption of aquatic and forest ecology. Air quality is deteriorated due to the release of residual, solid waste, gaseous emissions, and particulate matter from industry. Heavy metal contamination has a substantial effect on water bodies, changing water properties and lowering water quality. Heavy metalloids, solid wastes, and metallic content pollute soil properties, leading to a substantial reduction in soil quality. Industrial pollutants are responsible for aquatic eutrophication and acidification, disruption in the growth development process, microbial contamination, deteriorated water quality, disturbed marine ecology, and aquatic biodiversity. Industrial waste has a toxicological impact on organisms, destroys forest ecology, and changes the biochemistry of forest areas. Industrialization is necessary for a country's development and stability, but it must be achieved in an environmentally responsible way. Initiatives to make sure that industrialization is sustainable, both in terms of mitigating environmental damage and promoting more environmentally responsible industries, are desperately needed.

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Conflict of interest

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