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An Investigation of the Effects of Antibiotic Usage in Aquaculture on Destiny and Habits, Ecology, and Risk Analysis

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Abstract

Antibiotics have been an essential feature of animal farming and aquaculture since they appeared in experimentalsurroundings to address the increasing demand for animal-derived commodities. Aquaculture involves cultivating aquatic flora and fauna in controlled environments, serving as a top-notch provider of protein with elevated nutritional value. Consequently, Antibiotic Resistance Genes (ARGs) have evolved and spread extensively in the commercial farming of animals, which could harm the health of society. One Health provides a comprehensive analysis of livestock industry ARGs and mitigation measures. This review specifically delves into the human health risks linked to antibiotics and ARGs in cattle and aquaculture systems, aiming to elucidate the intricate interconnections of ARGs among animals, environments, and humans. Seafood Watch (SFW) addresses these issues by enforcing aquaculture rules, planning carefully, investing in research, policy coordination, and worldwide collaboration. The 15 articles were selected with great care and attention to detail according to PRISMA criteria. This review focuses on the following subjects: environmental impact, soil antibiotic entry and destiny, antibiotic use in aquaculture, antibiotic entry and fate in the water system, and assessing potential environmental risks. Ensuring a steady supply of safe aquatic goods for the expanding consumer market is the key to aquaculture's future. There needs to be increased financing for research into alternative marine health management systems and international regulatory and policy collaboration.

Keywords: antibiotic, aquaculture, Water System, Soil, animal husbandry

INTRODUCTION

Aquaculture involves the careful cultivation and management of aquatic flora and fauna to provide a reliable and abundant supply of premium protein.A substantial portion of the protein consumed by more than 56% of the global population comes from aquaculture-produced seafood and crabs (1). Aquaculture has lately emerged as the primary source of food fish production worldwide, and it is believed that aquaculture is responsible for supplying roughly forty-five percent of the fish consumed globally (2). The continuing reduction of wild fisheries worldwide has been a driving force behind this remarkable expansion, propelled by the rising demand for fish and seafood products (3).Aquaculture can increase algal production, decrease dissolved oxygen at the water-sediment interface, and enrich sediments with organic matter (4). One of the most common categories of feed additives used as growth promoters is antibiotics. Since, several antibiotics have found new uses in fish farming, particularly growth boosters. Antibiotics are blended with feed components at a sub-therapeutic level to keep the water clean and the food under control (5).Low taxation levels are likely to foster the expansion of aquaculture, which is estimated to provide around 109 million metric tons for human consumption by 2030 as opposed to the seventy-four million metric tons forecast from exploratory fishing (6).It is necessary to have aqua medicines on hand for many aquatic animal health-related tasks, including pond construction, water and soil quality maintenance, feed composition, reproductive manipulation, and transportation of live fish, growth activity, preparation, and the final product of added value (7).Many farms that produce fish dispose of their wastewater into rivers or use it as manure on farms. Unfortunately, this practice often leaves antibiotics in the

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water.By entering the food chain from these sources, the leftover antibiotics might cause problems (8). Ecosystem diversity, including phytoplankton and zooplankton, can be impacted by antibiotic residues. It has been suggested that some antibiotics, including tetracyclines, sulfonamides, and quinolones, could cause problems with the initial phases of zooplankton growth and phytoplankton chlorophyll synthesis (9).Aquaculture, propelled by extensive cultivation practices, has emerged as the most expanding sector in the global food industry, accompanied by a surge in the application of antibiotics.Consequently, abundant pharmaceutical-derived antibiotics exist in artificial settings, including sewage and wastewater treatment plants (WWTPs) (10).This study uses the newly available data to explain the impact, rule, and environmental destiny of antibiotics and their reduction methods. The study highlights the important knowledge gaps and future research directions to grab readers' interest in this contentious and fast-evolving issue.

THE SYSTEMATIC PROCESS OF REVIEW

Figure (1) shows that the systematic review aligned with the requirements specified in "the preferred reporting items for systematic review and meta-analysis (PRISMA) guidelines". The following databases were searched from Scopus, PubMed/MedlineandWeb of Science for papers that investigated the antibiotics' environmental effects. The keywords used were antibiotic, aquaculture, habits, and ecology. This research included a qualitative set of 15articles for analysis. Table (1) provides studies of antibiotic usage in aquaculture.

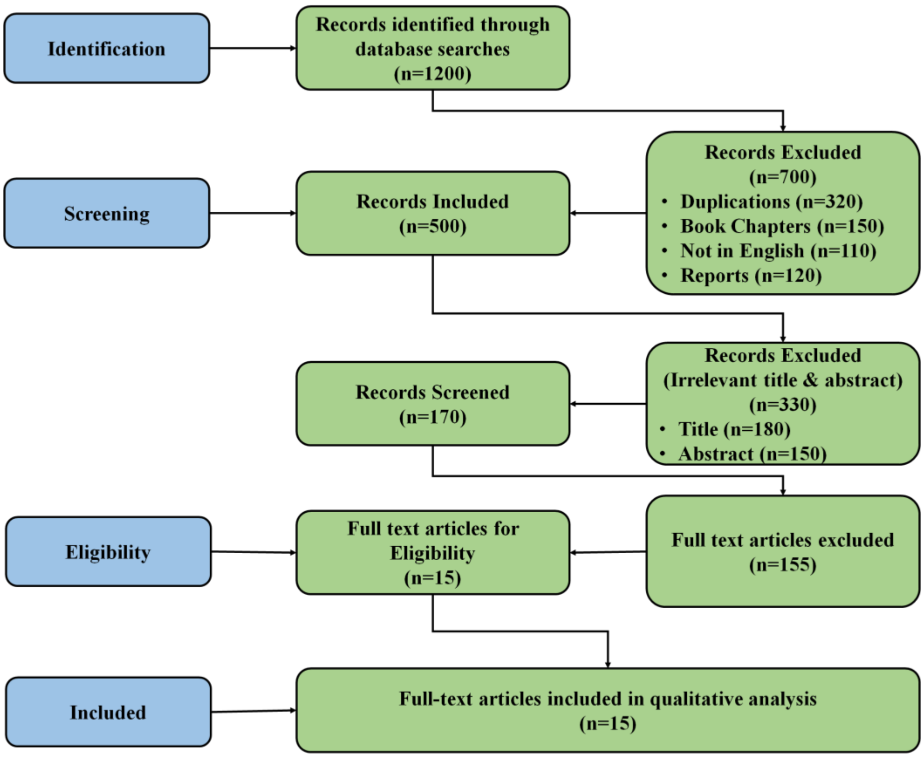

Figure (1). Diagram of PRISMA Flow (Source: Author)

Table (1). Studies of antibiotic usage (Source: Author)

No.	Highlights of the studies	References
1.	To compare farmed macroplastic-associated bacteria to water, sediment, floating macroplastics, and fish intestines.	(11)
2	Assessed the impact of AMR education on rural Bangladeshi aquaculture growers.	(12)

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3.	Antibiotic residues in produced aquatic creatures and bacterial resistance originate from intensive farming's indiscriminate usage.	(13)
4.	Discussed hotspot origins, behavior, and destiny in wastewater, health hazards, and risk factors of ARGs.	(14)
5.	Analyzed peptide polymers that inhibit harmful bacteria in aquaculture and avoid antibiotic resistance.	(15)
6.	Analyzed the distribution ARB and ARGs in shrimp aquaculture at differentstages.	(16)
7.	Determined that flumequine and florfenicol use is correlated with antibiotic concentrations found in surface waters.	(17)
8.	Discussed AMR detection approaches in aquacultures, including antimicrobial susceptibility, molecular, and fast tools.	(18)
9.	Due to antibiotic usage in aquaculture, column water and fish-associated microorganismsdevelop antibiotic resistance.	(19)
10.	An econometrics study to limit prawn farmers' usage of banned antibiotics in Southern Vietnam.	(20)
11.	For food and product safety, several governments have defined maximum remainingrestrictions and aquaculture antibiotic exclusion lists.	(21)
12.	Antibiotics can be found in effluent from aquaculture and household systems.	(22)
13.	Antibiotics persist and harm aquatic ecosystems, making them contaminants. Critical assessments of wastewater antibiotics and the latest antibiotic-eradication technology are uncommon.	(23)
14.	The addition of antibiotics to fish tanks resulted in effluents containing hundreds of μg/L, highlighting the necessity for control measures.	(24)
15.	The materialization of ARB in aquatic settings poses a substantial public health risk, with hospitals being a primary contributor to this concern.	(25)

Approach to the environment

In 2014, aquaculture was responsible for 44.11 percent of all fish production, making a rapidly expanding sector around the globe (11). To meet the growing demand for fish protein and polyunsaturated fatty acids, fish and seafood farmers are forcing themselves to engage in intensive farming practices (12). Due to the inherent characteristics of intensive fish farming, organisms experience various stressors, including elevated stock density and suboptimal water quality, leading to an environment that is favorable for the onset of diseases (13). Antibiotics and AMR pathogens enter the surroundings in an active form via agricultural runoff, which includes animal urine and feces (manure). Sludge and processed wastewater are important byproducts of wastewater treatment plants, which provide an additional source (14). One illustration involves the introduction of anthropogenic reactive gases (ARGs) into the environment through the utilization of sewage sludge as a fertilizer or soil enhancer or through the recycling of treated wastewater for irrigating crops.The third route is aquaculture, which routinely overuses antibiotics in the feed (15). While community landfills may not be as relevant to antimicrobial resistance (AMR), the leachate from municipal solid waste poses a serious risk of

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environmental contamination due to the disposal of antibiotics and other medications in residential trash cans (16).

Antibiotic entry and destiny in soil

Chemical, physiological, and biological reactions occur in the soil-water system when antibiotics, like any organic chemical compound, settle into the soil (17). The responses based on the antibiotics' specific animal and element characteristics, the soil's attributes, and the surrounding environmental conditions (18).There is an important connection between these processes, which may be classified as transport or deterioration. Various mechanisms, including adsorption/desorption, leakage, drainage, plant absorption, dispersion, and volatilization, convey the antibiotic from one soil phase to another or even within the same phase, as shown in Figure (2).

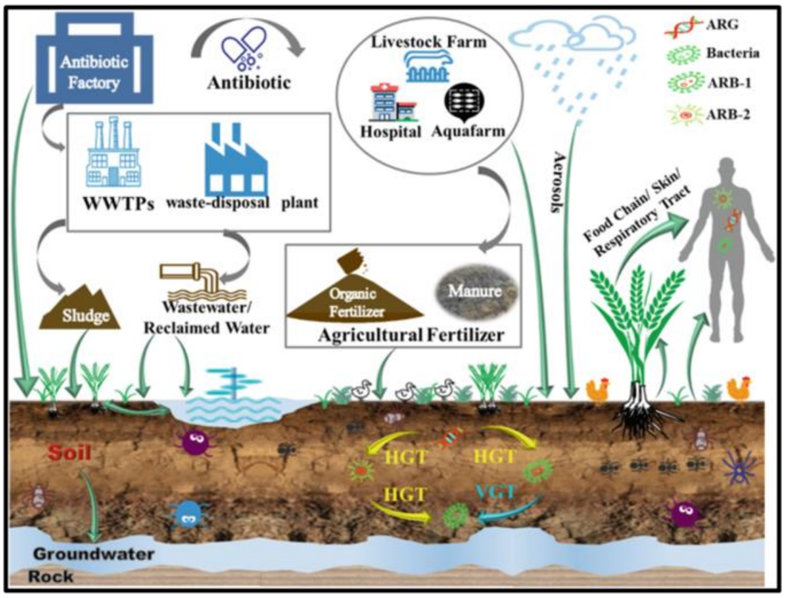

Figure (2). Antibiotic fate in soil (Source:https://media.springernature.com/lw685/springer-static/image/chp%3A10.1007%2F698_2020_562/MediaObjects/482950_1_En_562_Figa_HTML.png?as=webp)

Hydrolysis, sunlight, decomposition, oxygen loss, and reductions are all examples of transformation processes that alter the complex molecules' structural makeup (19). Decomposition and adsorption/desorption are the two most important processes regarding how antibiotics stay in soil or move to other parts of the environment, such as water or crops (20).

Antibiotic Usage in Aquaculture

Orally given antibiotics are metabolically inert and eliminated in the urine or feces at a low to average rate. Discarded food also includes antibiotic metabolites, fish waste, and other byproducts of environmental deterioration (21). Over seventy percent of the antibiotics used to fish feed in industrial fish farms wind up in the background via evaporation.Accumulation of antibiotics and their derivatives in water sediments disturbs the fragile equilibrium of the ecosystem by causing changes in the composition of local microbial populations (22). However, the overall microbial profile and ecological stability are severely compromised by the persistent presence of a multi-drug-resistant facade in the environment, as shown in Figure (3).

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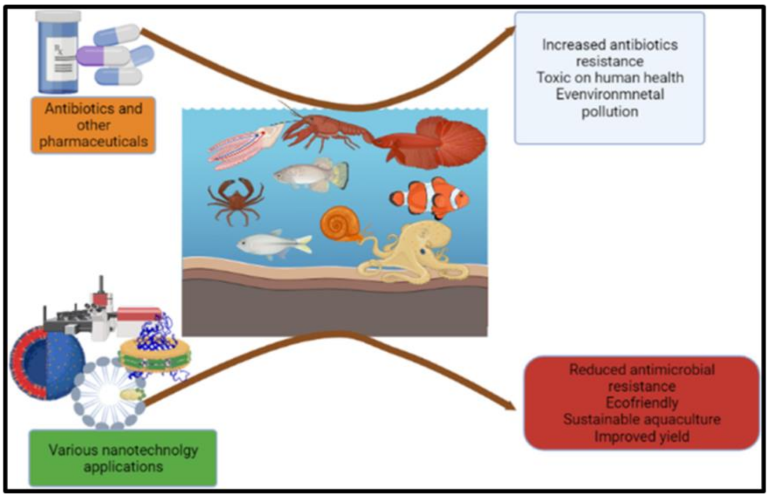

Figure (3). Antibiotic usage in aquaculture (Source:https://media.springernature.com/lw685/springer-static/image/art%3A10.1007%2Fs11356-022-22319-y/MediaObjects/11356_2022_22319_Figa_HTML.png?as=webp)

In aquatic environments, antibiotics harm non-target/indicator species, including algae, plant life, and microbes. Aquaculture producers often use antibiotics for preventative or therapeutic reasons to reduce the incidence of bacterial illnesses and their subsequent spread (23). This is particularly relevant in nations where there are no other preventative measures in place.SFW works to address these issues by ensuring the strict application of laws governing aquaculture, exercising caution when planning, investing in research, coordinating policies, and networking globally.

The water system of antibiotic Entry and Destiny

The escalating demand for Earth's limited water resources underscores the critical need to prioritize the safety of drinking water, especially given the continuous and rapid expansion of the global human population (24). Numerous researches have lately aimed tooccurrence and destiny of antibiotics in water ecosystems worldwide. The chemical products of antibiotics that can be utilized in livestock husbandry make their way into the water cycle via various means, such as the spread of manure or slurry to fields where pasture-raised animals poop. They can be carried by wind, run off the land's surface, or seep into the groundwater (25). The effects of several medicines that are effective against bacteria found in wastewater. Bacteria with resistance or multiple resistance mechanisms may enter the food chain by using sewage sludge as an irrigation manure or wastewater. Wastewater and sewage treatment facilities have been shown to include resistant and multi-resistant microorganisms (26).

Environmental Risk Analysis

The aquaculture sectors face risks from the extensive use of antibiotics, which can result in incorrect use, insufficient elimination, and delayed breakdown of antibiotic compounds in water bodies. Excessive concentrations of residual antibiotics, including fluoroquinolones, macrolides, and tetracyclines, pose environmental risks due to their accumulation (27). Appropriate criteria and suggestions specifying safe antibiotic concentration limits are required to quantify these dangers. Monitoring systems are costly and sophisticated. Antimicrobial concentration within the surroundings is a crucial component in their usage. Employing the Veterinary International Conference on Harmonization (VICH) approach, the environmental risk assessment aims to determine whether the estimated hazardous dosage of chemotherapeutics exceeds the dosage anticipated to cause no adverse effects in toxicity testing (28). Recommendations include implementing grassroots microbial diagnostics and environmental surveillance efforts, particularly establishing standards for

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assessing the potential risks to aquatic life in specific locations (29).Antibiotics in aquaculture provide ecological hazards such as antibiotic resistance, freshwater residues, and accidental consequences on species that are not targeted (30). Overuse of antibiotics can lead to resistance, impacting microbial ecosystems and aquatic creatures (31). Residual antibiotics in sediments and water can also affect people's health. Among the ideas, there have been appropriate antibiotic usage and other therapeutic alternatives (32).

RESULT

The Impact of Antibiotic Use in Aquaculture

Aquaculture is an important business that relies on antibiotics to fight bacterial infections. These medications can be used prophylactically, therapeutically, or metaphylactically and can increase growth (33). A variety of antimicrobial classes, including tetracyclines,aminoglycosides, chloramphenicol,quinolones, nitrofurans, sulfonamides, lincosamides, and poly-complexes, and lactams, are employed for their antibiotic properties. Unfortunately, in underdeveloped countries, antibiotic use is unregulated, leading to widespread and indiscriminate usage.Although developed nations have regulatory bodies to ensure rigorous compliance, the present amounts of antibiotics utilized in agribusiness must be discovered (34).Antibiotics are essential for disease prevention and treatment in aquaculture systems, lowering morbidity and mortality in farmed fish populations.Conversely, over-reliance can result in antibiotic-resistant bacteria weakening their efficacy and spreading to other species or people. Antibiotics' environmental effects can taint natural water sources and cause human health risks (35).Antibiotics are useful in treating a wide range of ailments, but the employof continuity can guide to antibiotic resistance, a drug's capacity to prevent microbial development effectively. Several bacteria genes in the colon are resistant to medicines such as vancomycin, bacitracin, cephalosporin, and tetracycline. The community of bacteria in the gut regulates the immune system, metabolic processes, and overall health. Antibiotics treat and combat illnesses caused by microorganisms, but their long-term usage causes susceptible microorganisms to acquire immunity, as shown in Figure (4). The rise of antibiotic resistance in bacterial infections has increased mortality and diseases that endanger human life(36).

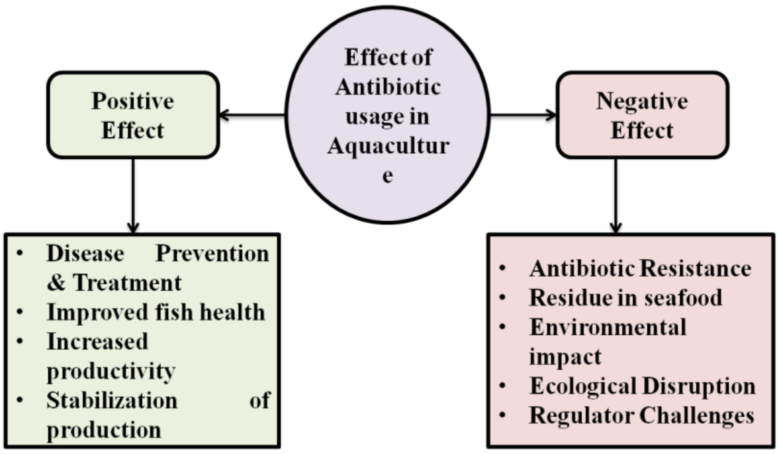

Figure (4). Positive and Negative Effects of Antibiotic Use in Aquaculture (Source: Author)

Positive Impact of Antibiotic Use in Aquaculture

Antimicrobials are necessary medications for people's wellness because they suppress bacterial growth. They comprise a complicated compound with several functional groups that are classified depending on their modes of operation. They have been employed to promote the welfare of animals in the field of veterinary medicine, particularly aquaculture. Antibiotics are used for prevention, treatment, and metaphylaxis. Gentamicin, gentamicin, and antibiotics are widespread antibiotics used in agriculture globally, particularly used in European nations and the waters of the Mediterranean region (37). Figure (5) shows data on how economical antibiotic

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production and sales sector growth will increase. Farmers mostly used antibiotics to treat unhealthy fish orally, with mostly used *oxytetracycline* and *amoxicillin,* followed by *Ciprofloxacin, Sulfadiazine, Chlortetracycline,* and *Azithromycin.*

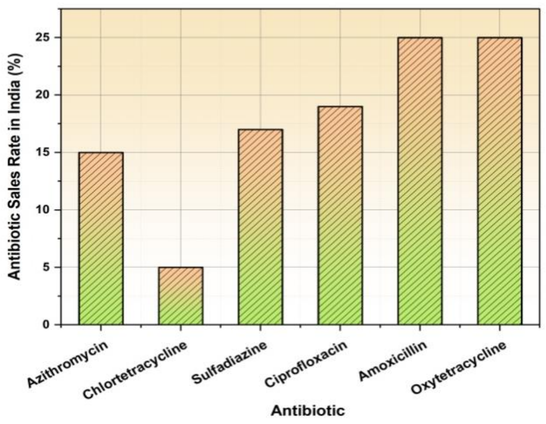

Figure (5). Antibiotic Sales Rate in India (Source: Author)

Antibiotic usage can have a significant influence on fish health.*Ciprofloxacin*(38), a broad-spectrum antibiotic, may treat many bacterial illnesses in fish, but overuse or misuse can lead to antibiotic resistance. Although *sulfadiazine*, a sulfonamide antibiotic, has wide antibacterial action, excessive dosing or withdrawal periods may result in residues in fish tissue. *Chlortetracycline* (39), which kills positive and negative bacteria in fish, can compete with antibiotics if applied incorrectly for an extended period. *Azithromycin* (40), a macrolide antibiotic with wide bactericidal action, has the potential to remain in the environment and damage organisms that are not its intended target. To reduce side effects, antibiotics must be used responsibly, which includes appropriately diagnosed, complying with dose and delivery techniques, and adhering to discontinuation durations. Adaptation administration, such as antibiotic rotation and exploring alternate disease treatment techniques, is also critical.

Furthermore, pharmaceuticals can reach the natural world via agricultural waste products, potentially damaging the environment. As a result, antibiotic usage and environmentally sound aquaculture techniques are critical for preserving the integrity of fish while eliminating the negative consequences. The antibiotic consumption and production rate in Figure (6) fish culture countries are depicted.

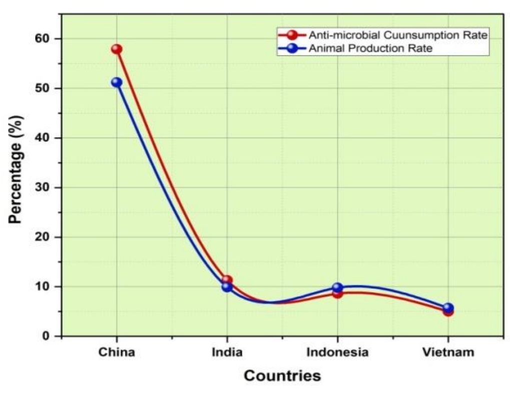

Figure (6). Antibiotic Consumption and Production Rate (Source: Author)

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CONCLUSION

The use of antibiotics in India's aquaculture industry raises significant worries regarding public health and the environment. By guaranteeing the stringent implementation of aquaculture regulatory laws, cautious planning, and making investments in research, policy coordination, and global cooperation, SFW seeks to solve these difficulties. The study's objective is to decrease the amount of antibiotics used per unit, provide aquatic food that is safe to eat and safe for the ecosystem, and standardize the evaluation of antibiotic consumption.The consequences anticipated in a specific farming and ecological context can be gauged by examining the use of antibiotics. Therefore, to explore the danger of chemical usage, the SFW Aquaculture Standard's evaluation technique and criteria use the findings of the developed risk methodology. An initial risk assessment method that aquaculture stakeholders can use, and it should be integrated to measure the potential environmental effects of antibiotic use on the farm or farms being assessed more accurately. According to recommendations from various writers, the aquaculture industry must establish a standardized surveillance system for monitoring antibiotic intake. Robust monitoring data will facilitate a better consideration of trends in antibiotic resistance and contribute to enhanced comprehension of the fisheries industry, including its sectors, output, and consumption patterns.Since aquatic and marine systems for aquaculture differ greatly, they deserve to be handled and examined differently. Dumping human waste collected in airplanes into the middle of the sea causes various diseases; burying dung in the soil can increase the amount of nitrogen in the ground, and nitrogen-rich soil can increase the yield of agricultural land.

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