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New Zealand, Pollution of Rivers and Lakes

The Pollution of New Zealand's Rivers and Lakes

New Zealand is an island country in the South Pacific Ocean. New Zealand has nearly 270,000 square kilometers of total land area and around 5 million people on two main islands and many smaller islands. The climate is primarily temperate with some regional contrasts, making it ideal for agriculture. Indeed, 43.2% of the land was used for agriculture by 2018 ("The World Factbook"), and dairy, eggs, honey, meat, wood, fruits, and nuts took up nearly 60% of New Zealand's exports by 2020 (Workman).

The average New Zealand family is a nuclear family. As people become more individualistic, most families are growing smaller, although the native Māori have more children as the fastest-growing ethnic population. Māori traditions link families and the land, even adopting other Māori to continue their culture of kinship ("Culture: Family"). The average New Zealand house is located in an urban area. It is structured similarly to those of the U.S. but with an average size of 1220 square feet (Jackson), about half the size of the average U.S. house (McGill). The average diet is largely continental; although some variations depend on region and ethnicity, they have no significant impact on nutrient consumption (Pearson et al.).

Ranked 7th overall in the Best Countries ranking (U.S. News), New Zealand provides mandatory education from 6 to 16 (Stats NZ), universal healthcare ("New Zealand Healthcare System"), and various public facilities. Overall, New Zealand is a very stable country with a bright future. However, according to a national survey, around 82% of New Zealanders reported that they were very concerned about one issue: the pollution of their rivers and lakes (Cosgrove).

Due to high rainfall on many mountains, New Zealand has many rivers and lakes. Although small streams are excluded, New Zealand has mapped over 180,000 kilometers of rivers. This abundance made them significant to New Zealand's culture. Early Māori built settlements around river mouths, fished from rivers, and traveled on them in canoes and rafts. To this day, Māori tribes claim special rivers in a spiritual bond. Modern New Zealanders also use rivers for fishing and kayaking (Young). Lakes cover about 1.3% of New Zealand's total land area. They have many uses such as fishing, boating, swimming, irrigating, and even drinking (Nathan).

Data collected by New Zealand's regional councils and unitary authorities note that two-thirds of New Zealand's rivers are too contaminated to swim in due to impaired ecological health and bacterial contamination. Some government-affiliated researchers report that urban areas are most contaminated, followed by pasture and exotic forests. They also claim that "the toxic effects of nitrate and ammonia on aquatic ecosystems are an issue at only a small percentage of sites ("Two-thirds")." Independent scientists disagree with this statement. They say that the availability of irrigation water led to an increase in agriculture and related fertilizers, which in turn led to animal waste containing nitrogen and phosphorus washing into rivers (One Health). Some note that since 0.8% of rivers are in urban areas and 40% in pastoral areas when considering river length, the government's report that urban areas are most contaminated is questionable. Individual economists, foreign scientists, and even other government-affiliated researchers also note nitrogen as the most significant cause of water pollution (Zalk et al.).

The pollution of rivers and lakes has many adverse effects. In 2019, New Zealand's environment minister stated that three-quarters of New Zealand's native freshwater species were threatened by extinction (Roy).

Excessive nitrogen and phosphorus from fertilizers cause algae overgrowth. This overgrowth uses up oxygen and blocks light, making aquatic life unable to get enough oxygen (Khadka). People suffer as well: in August 2016, five thousand people from the town of Havelock North suffered an outbreak of gastroenteritis from drinking water. It was one of the largest waterborne outbreaks in the developed world and was caused by sheep waste contaminating the water supply (One Health). Around 35,000 New Zealanders get sick from subpar tap water every year, and about a third of wastewater treatment plants have been caught breaching consents ("Three Waters").

In nature, nitrogen reacts with oxygen to produce nitrate; although nitrate is an essential component of living things, consuming nitrate-rich water can decrease blood cells' oxygen-carrying capacity and increase the risk of recurrent respiratory infections, thyroid dysfunction, adverse reproductive outcomes, and even certain cancers. Although humans can irrigate gardens and bathe in nitrate-rich water as long as they don't drink it, animals can get sick from excess nitrate (*Oregon.gov*). Nitrate poisons aquatic animals by converting oxygen-carrying pigments to forms that can't carry oxygen. Freshwater animals are more vulnerable than marine animals; freshwater invertebrates, fish, and amphibians can get sick by a nitrate concentration of 10 mg nitrate-nitrogen per liter, which is the U.S.' federal maximum level for drinking water. The most sensitive freshwater species can stand a maximum concentration of 2 mg nitrate-nitrogen per liter (Carmargo). This shows that nitrate is the cause of New Zealand's freshwater species' endangerment: New Zealand's maximum acceptable level for nitrate is 11.3 mg nitrate-nitrogen per liter, and that's for drinking water (*Canterbury District Health Board*). It can be inferred that the water in rivers and lakes has even more nitrate.

Nitrate harms farm animals as well. Nitrate itself isn't too toxic; however, in the digestive tract of herbivores and ruminants, grazing mammals that ferment food in a special stomach before digestion, bacteria convert nitrate into nitrite, which is easily absorbed and ten times more toxic than nitrate (Harty and Olson). Farm animals can consume high nitrate levels not only through water but through grazing on nitrate-rich pastures. Under ideal conditions, plants don't contain too much nitrate as they convert nitrate into protein to grow. Overfertilizing, droughts, watering with nitrate-rich water, and cold weather can cause high nitrate levels. High nitrate levels can cause oxygen deprivation, lost pregnancies, and gradual degeneration of organs (Kallenbach and Evans). These symptoms are especially detrimental to New Zealand, as dairy is its largest industry.

New Zealand's government is very aware of these problems. It conducts water quality-related research primarily through NIWA, the National Institute of Water and Atmospheric Research. Other Crown Research Institutes, government-owned companies focusing on research, also contribute to environmental research. Collaborative efforts with other organizations have also been made. The most prominent effort related to water quality is Land, Air, Water Aotearoa (LAWA), a collaboration between regional councils, the Ministry for the Environment, the Department of Conservation, and several institutes and foundations. Every district council runs a district health board that provides information about local water supplies, notably including a section about nitrate in drinking water. The government is also attempting to unify treating and transporting systems for drinking water, wastewater, and stormwater to preserve water quality and prevent wastewater overflows ("Three Waters").

Strangely, NIWA and LAWA seem to hold contradictory views. In a 2017 article titled "Our land and water and NIWA's role," NIWA lists nitrogen, phosphorus, sediment, and microbes as key contaminants, agreeing with independent scientists; however, in the article quoted in paragraph 4, LAWA says the effects of nitrate, which includes nitrogen, isn't that widespread. Why would the government contradict itself?

This contradiction is most likely because the government has to consider the people and the economy as well as the environment. A good example of this consideration is Our Land and Water National Science

Challenge, a government-funded program that employs researchers from various backgrounds to focus on preserving New Zealand's land, water, and associated ecosystems ("About"). It has spearheaded valuable water quality research, such as mapping natural denitrification capacity (Singh, Ranvir et al.) and discovering that the majority of pollutants come from small areas of a farm or catchment ("Future Resources"). However, there has been no significant effort to denitrify already-polluted waters. In theory, this lack of artificial denitrification would be fine as natural denitrification by freshwater organisms would persist without further increases in pollution; in practice, New Zealand's water quality is continuing to drop. This is because agriculture, and dairy farming in particular, continues to create an overflow of nitrogen.

As shown in the first paragraph, agriculture is New Zealand's biggest industry, taking up nearly half of its land and more than two-thirds of its exports. Out of the agriculture industry, dairy is the most prominent, taking up nearly a third of overall exports ("How big dairy industry"). That's nearly half of the agricultural sector taken up by dairy alone. Unfortunately, New Zealand's dairy farming is centered around farming large herds on pastures (Granwal), leading to significant nitrogen waste runoff. The current Ministry for the Environment, aware of the effects of farming on rivers and lakes, created regulations such as freezing land intensification permits until regional councils created freshwater protection plans and only allowing new irrigation or dairying when it won't increase pollution. Despite offering nearly 150 million US dollars to help affected farmers, farmers' lobby and advocacy groups heavily protested the plans (Roy). This backlash spells trouble for future projects to control and reduce nitrate, as, with current technology, to reduce nitrate to safe levels means to lower the number of cows (Zalk et al.).

As long as the dairy industry makes money, lowering the number of cows won't be viable. Harming the economy and, thus, people's livelihoods in the name of conservation would make them turn against future conservation efforts, damaging the environment in the long run. Therefore, New Zealand will have to invest heavily in new technologies that would help remove nitrate from river water. Denitrifying methods such as nanotechnology, reverse osmosis, ion exchange, and electrodialysis are commonly used for drinking water. However, they are expensive and leave nitrate waste brine behind, making it difficult to use for rivers and lakes (Mohseni-Bandpi). The most viable method seems to be biological denitrification.

Biological denitrification, also called microbial denitrification, utilizes bacteria to remove nitrate from water. These bacteria use nitrate instead of oxygen for respiration. Used nitrate is turned into nitrogen gas, which doesn't harm the environment nor require waste disposal. Setting up the bacteria is also relatively cheap and easy, as the bacteria only need to be attached to a carbon source they can oxidize. Furthermore, the process can reach a nearly 100% nitrate removal rate unmatched by other methods. For efficient denitrification, a large biomass with denitrifying bacteria and carbon needs to touch nitrate-rich water with little oxygen and, preferably, an external carbon source (Ingole and Burghate). New Zealand's rivers and lakes fit this description perfectly: due to high nitrate levels, algae overgrows, depletes the water's oxygen, and decomposes into large amounts of carbon dioxide (NOAA).

Although biological denitrification may seem like a perfect fit as of now, there is still work to do. Despite its many advantages, biological denitrification isn't widely used for drinking water and underground water due to microbial contamination (Ahmadi). Microbial contamination is a given since the bacteria directly contact the affected water and grow there. This is where New Zealand should focus its research: if the denitrifying bacteria contaminates the water too much, denitrifying would harm the endangered native freshwater species rather than restore them. There are over 125 types of denitrifying bacteria in over 50 genera and around 10 ~ 15% of the total bacteria population in water, soil, and sediment (Eldor). With such a variety, it is more than likely that there will be at least one species that won't harm the environment. There are other options if there isn't a 'safe' species, as all living organisms use nitrogen in nitrates to grow. Aquatic plants such as canna are known for efficient denitrification (Y. Chen et al.), some species of fungi were able to break down nitrates and nitrites (Shoun et al.), and even blue-green algae were reported to denitrify waters (X. Chen et al.). These options, however, are less efficient and still have the potential to harm native species, which is why identifying beneficial denitrifying bacteria should come first.

When working on perfecting the biological denitrification process, the effects on surrounding communities should also be considered. When deciding which type of bacteria to use, any type of denitrifying bacteria with a known precedent of causing harm through human consumption, no matter how insignificant, should be disqualified to preserve the health and trust of locals. Considering the prominence of New Zealand's agricultural industry, the bacteria should not harm any farm animals. The process should also be thoroughly explained to local Māori: the Māori traditionally believe that all water is imbued with unique 'mauri', or life force, from their ancestors, and thus should be treated with respect (Williams). To convince the Māori that biological denitrification is a good thing, New Zealand's government should explain how the process will ultimately better water quality and thus better their quality of life.

New Zealand's government should consider collaborating with pre-existing organizations to boost efficiency. Many universities have institutes related to water quality; recently, the University of Auckland Institute of Marine Science found mussels could increase marine sediment denitrification by up to 2,500 percent (Hillman and Miles). If the government provided funding for research related to freshwater denitrification, New Zealand would acquire both professional researchers' focus and students' interest. Thus, working with universities should be prioritized for long-term benefits. Corporations are also a viable option: many companies specialize in improving freshwater quality, with some even working with regional councils to manage local ponds, lakes, and streams ("Case Studies"). Utilizing their experience in the field would be very beneficial. In addition, incentivizing large companies to research green technology may help. In 2016, Fonterra, New Zealand's largest dairy company, reported developing a new wastewater treatment technology that turns the dairy solids from their wastewater into fertilizer. Similar ventures should be actively encouraged as such developments benefit both the business and the environment.

Throughout its history, New Zealand has flourished by making the most of its natural resources. Now it is time to preserve those natural resources for future generations. New Zealand's rivers and lakes are polluted due to high nitrate levels from farming; to combat this, New Zealand should invest in biological denitrification research as it is the most realistic option. Through new technology, New Zealand can preserve both its environment and economy.

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