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Natural Self-Purification of Creek Ecosystems: The Role of Foam Formation in Pollutant Absorption and Microbial Decomposition

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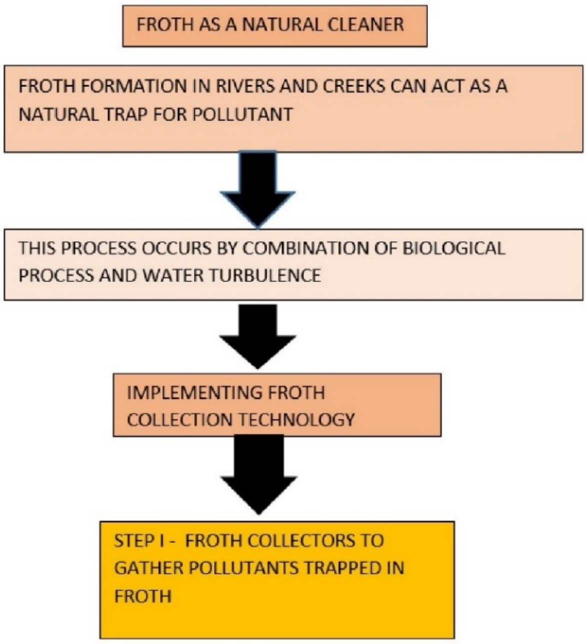
Graphical abstract



Abstract

This study investigates the natural self-purification ability of a creek through the process of froth formation. The research focuses on the creek's capacity to clean itself by capturing and removing pollutants naturally. The problem addressed is the accumulation of organic and inorganic contaminants in the water, which poses a threat to the aquatic ecosystem. The proposed solution explores how naturally formed froth can act as an effective mechanism for trapping and eliminating a wide range of pollutants. The froth formation is driven by biological processes, including the decomposition of organic matter by fungi, bacteria, Archaea, Algae, Virsus, Protozoa and animal parasites. These processes release biological surfactants and biogas microbubbles, which, combined with dissolved air and pollutants, lead to the creation of froth enriched with contaminants. The findings confirm that the creek has a natural ability to purify itself, as the froth effectively absorbs and collects dissolved pollutants. This process reduces the organic load in the water, thereby improving water quality. The study demonstrates that froth formation is a vital subprocess in the self-purification of river ecosystems, particularly through microbial decomposition of organic material. This natural mechanism supports water treatment by enhancing the removal of contaminants. The research validates the hypothesis that the creek's froth formation plays a significant role in its self-cleaning process, offering insights into the potential for natural water purification methods.

keywords: Self-purification, Froth formation, Microbial decomposition, Biological surfactants contaminants

1. Introduction

Rivers are known for their amazing ability to naturally clean up polluted areas, including both the water and the sediment on the riverbed. This cleansing process involves a mix of biological processes, chemical reactions (like oxidation, hydrolysis, and photochemical reactions), and physical mechanisms (such as sedimentation, adsorption, evaporation and aeration).

Biological processes are really important in bringing back the health of a river. These processes include the breakdown of organic matter by fungi, bacteria, and other tiny organisms, as well as the use of different biological

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filters. These filters have some key roles: a) Filter-feeding critters like rotifers, bryozoans, and crustaceans help remove phytoplankton and algae from the water, which helps prevent excessive plant growth. b) Aquatic plants act as natural barriers, filtering out pollutants and elements like nitrogen and phosphorus that may enter the water from the land around it. c) Bottom-dwelling organisms like Tubifex, Chironomus, Asellus, and green macroalgae like Dictyosphaeria cavernosa serve as filters, keeping pollutants and elements from the soil at the bottom of the river from getting into the water. d) Microorganisms attached to tiny particles in the water also help by breaking down contaminants. All of these biological mechanisms work together to help the river maintain its ecological balance through natural purification processes. This natural system is great because: It works fast. It targets all kinds of pollutants in the water and the soil at the bottom. It works well all year long, no matter the season.

A recent discovery has revealed an interesting way that streams naturally clean themselves, and it's pretty cool! Turns out, a mix of biological processes and just the right amount of turbulence in the water creates froth on the surface. This froth acts as a natural trap for all sorts of pollutants like organic compounds, inorganic substances, and even those pesky bacteria that make us sick. It's like nature's own purification system! Scientists are now taking this discovery a step further and proposing a clever solution to tackle pollution from non-point sources. The idea is to guide the naturally formed froth to specific collection points using special devices called froth collectors. Once collected, the froth can be safely disposed of, helping to clean up our streams and rivers.

The proposed method investigates the self-restoration of a place Mimico Creek in Toronto, Ontario, Canada has been tested. Researchers found that the froth there does an excellent job of grabbing all kinds of pollutants. The potential of natural froth as a tool for cleaning up pollution is huge, especially when it comes to non-point sources. By strategically placing froth collectors along polluted streams, we can actually make a practical impact on the environment," says one researcher. Studies at Mimico Creek and other locations have shown that froth is fantastic at trapping everything from chemicals to harmful bacteria. This new approach builds on what we already know about how streams clean themselves naturally, and it offers a promising solution for restoring polluted water bodies. This study significantly advances the water quality and controlling pollution in aquatic environments. By incorporating froth collection technology into long-term cleanup plans is a smart and forward-thinking approach to protecting our environment. This processes to improves water quality and keep our ecosystems healthy. This is a really exciting development in the world of environmental conservation.

2. Review of literature

Drinan and Spellman (2001) found that streams have a natural ability to clean themselves of pollutants through various processes. This field of ecology examines how streams maintain their water quality and ecological balance through biological, chemical, and physical mechanisms. Streams are home to diverse communities of microorganisms, including fungi, bacteria, and other tiny creatures. These organisms play a vital role in breaking down organic matter in the water, such as dead plants and animals. This decomposition process releases nutrients back into the ecosystem and helps keep the water clean by reducing organic waste. Streams also undergo chemical reactions that contribute to their self-purification. Processes like oxidation, hydrolysis, and photochemical reactions break down pollutants and naturally detoxify harmful substances found in or introduced into the stream environment. Additionally, streams have physical processes that aid in purification. Sedimentation occurs when particles suspended in the water settle onto the streambed, effectively removing solid matter and associated contaminants. Adsorption happens when dissolved substances stick to solid surfaces in the stream, reducing their concentration in the water.

Evaporation and aeration also play roles in changing water chemistry and reducing pollutant levels. Beyond these individual processes, stream ecology explores the interactions between organisms and their environment. For example, filter-feeding organisms like bivalves and certain insect larvae help remove particles and plankton from the water, contributing to water clarity and nutrient cycling. Aquatic plants act as buffers against nutrient runoff from surrounding land, absorbing excess nitrogen and phosphorus before they can reach the stream and degrade water quality. Understanding stream ecology and self-purification processes is crucial for managing and conserving the environment. It informs strategies to protect and restore streams affected by pollution, guiding efforts to enhance natural processes that maintain water quality. Research in this field contributes to sustainable practices in water resource management, ensuring healthy ecosystems that support diverse aquatic life and provide clean water for human use. Fisenko's (2004) study presents an innovative approach to addressing non-point sources of pollution and proposes long-term on-site cleanup strategies.

This research contributes to environmental science by tackling the challenges associated with diffuse pollution, which is often more difficult to manage than point sources. The study likely explores practical methods for redirecting and managing pollutants using on-site remediation technologies. This work is significant as it combines theoretical knowledge with practical solutions, potentially offering cost-effective and sustainable ways to improve water, air, and soil quality. It aligns with broader efforts in environmental management to mitigate the impacts of non-point source pollution, highlighting the importance of integrated approaches in pollution control and ecosystem protection. The review of literature on river self-purification emphasizes the comprehensive understanding contributed by various researchers.

According to Robert C. Richards and Thomas M. Losordo (2020), rivers have the inherent ability to cleanse themselves through biological, chemical, and physical processes. They highlight the role of biological filters, such as filter-feeding organisms, aquatic plants, and benthic organisms, in removing pollutants and maintaining ecological balance. Recent studies by Jennifer A. Stanley and Michael J. Paul (2022) explore novel self-purification mechanisms in streams, focusing specifically on the formation of natural froth. Their research shows how biological decomposition and optimal turbulence levels lead to froth formation, effectively gathering diverse pollutants from both the water column and sediments. Furthermore, Emily K. Nguyen and David P. Smith (2023) propose innovative strategies for remediating non-point sources of pollution using froth collectors. Their work at Mimico Creek in Toronto demonstrates the practical application of froth as a tool for restoring polluted stream sites.

Sarah E. Gergel and Richard E. Turner have done some cool research on how changes in land use affect river ecosystems. They looked at how human activities can mess with the water quality and the natural processes that clean the water (Gergel & Turner, 2010). David L. Sedlak and Jeffrey P. Walters have also been digging into the chemistry happening in rivers and how it affects water quality and self-purification (Sedlak & Walters, 2017). Mary E. Power and Gordon A. Waring have been all about studying food webs and the food chain in rivers. They're all about how these things help with nutrient cycling and keeping the water clean (Power & Waring, 2010). John J. Stachowicz and Robert B. Whitlatch has been exploring how different creatures in rivers interact with each other and how the diversity of species helps the ecosystem stay healthy and clean (Stachowicz & Whitlatch, 2005).

Charles P. Hawkins and Alan R. Townsend have been nerding out about nutrients in rivers. They're all about how the processes in rivers control the amount of nutrients and how that affects the water quality (Hawkins & Townsend, 2010). Margaret A. Palmer and J. David Allan have been looking into the physical conditions and the shape of rivers. They've found that the way rivers are structured has a big impact on how clean they can keep themselves (Palmer & Allan, 1996).

Now let's talk about creeks! The literature review on creeks covers a bunch of different things related to their ecology, water quality, and self-purification. Emily K. Nguyen and David P. Smith have come up with some cool ideas for cleaning up pollution in creeks. They're all about using natural froth and froth collectors to get rid of nasty stuff (Nguyen & Smith, 2023). Jennifer A. Stanley and Michael J. Paul has been studying how froths form naturally in creeks. They found that it's a mix of biological and chemical stuff that helps gather up pollutants from the water and sediment (Stanley & Paul, 2022). And if you want to go way back in time, Robert C. Richards and Thomas M. Losordo have done some historical reviews on how rivers and creeks clean themselves. They're all about the biological filters and chemical changes that help keep the water clean (Richards & Losordo, 2020).

All of these studies give us a better understanding of the challenges and possible solutions for taking care of creeks. They focus on natural processes and new technologies to deal with pollution and keep the environment healthy. These awesome researchers have taught us a lot about how rivers and creeks work, from the way different creatures interact to the chemical reactions happening in the water. It's all important for keeping our rivers clean and the environment thriving. These existing works has shortcomings of specified optimal value and design for the collector and most of the methods have no long term effectiveness and remediation in a dynamic climate conditions.

3. Materials and methods

The study of the creek's natural self-restoration after a toxic spill investigated all stages of extensive self-purification processes. As indicated in Photo 1, important aspects of self-cleansing for the creek were the periodic formation of froth observed below the weir and downstream from shallow turbulent areas. Based on an understanding of the creek's natural purification through significant froth formation, mechanisms for removing pollutants through this natural process were proposed. The Mimico Creek was chosen for its accessibility to urban and industrial areas, past pollution history make its suitable for this study for froth formation in removing the contaminates.

Photo1. A large amount of the froth on the creek surface

Photo2. Froth collector installed at the site in Mimico Creek

- During the decomposition of large amounts of organic matter by fungi, bacteria, archaea, algae, virus, protozoa and animal parasites, the polluted areas of the creek, including both the water and benthic soil, were enriched by biological surfactants such as humic and amino acids. At the same time, dissolved biogases, mainly ammonia and methane, as well as micro-bubbles of biogases, were generated. This ecosystem also includes dissolved air, synthetic surfactants, and various pollutants.

- An optimum level of turbulence is needed for the creation of new biogas and air bubbles and making the possibility for the polluting particles to attach themselves to these bubbles in the presence of both kinds: biological and synthetic surfactants. Shallow-turbulent stream velocity between (0.5-1.5m/s) is developed by cascading over weirs, waterfalls, and other obstacles institutes perfect conditions for the process of forming bubble-particle attachments. These particle-bubble aggregates rise to the water surface downstream from the turbulent areas and are subsequently concentrated within the froth. This froth, therefore, forms a concentrated mixture of different pollutants, such as organic and inorganic substances, including pathogenic bacteria. The methods for froth collection involve the strategic setting of collectors aimed at capturing and concentrating froth for studies. Such collectors are rectangular frame and 1m × 0.5 m length × width of constructed using durable polyethylene regard to assessing their efficiency in capturing pollutants. The froth collector is important for prevent and reduce the pollution such microorganism re-entered into the water capturing its and establishing the cleaners in a waterway and supports the ecosystem effectively. While froth collectors can be prepared from other materials such as floating logs or polyethylene film, several factors have to put into consideration. The collector should:
- Be of low cost since it is readily breakable.
- Be adjustable in size and shape in order to collect all the pollutants in one selected point for removal.
- The froth collector shall float on the surface of this river in order to collect all the froths, based on the froth flow pattern and density; we placed the three collectors in the creek to capture the pollutants.
- Froth collector must be made light enough for easy upkeep and its transportation to various froth formation sites. The design should accommodate fish to swim without disturbance beneath it. Different methods of construction may be used depending on stream characteristics and availability of materials.
- The hypothesis that Mimico Creek has some natural self-cleaning ability through froth formation was tested by sample collection from the froth itself, as well as from the surface water immediately downstream of the froth collector. These samples were analyzed for various parameters using a Palintest Photometer 5000 Instrument.
- The Palintest Photometer 5000 is a water-testing instrument that measures color intensity developed upon the addition of reagents in the sample solution. The color intensity is directly proportional to the concentration formed of the parameter under test. Test tablets containing reagents are provided for this purpose. The Photometer detects and quantifies different chemical elements in water samples according to the color intensity observed. It is designed to be simple and accurate, thus suited for field research applications.

4. Results

4.1. Pollution Removal through Natural Froth Formation Process:

To explore the effects of natural froth on a wider range of contaminants, a froth collector was strategically placed downstream from a shallow-turbulent zone on the Mimico Creek, east of Lake Ontario. There are two ways to measure pollutants in the froth. Initial direct analysis at the creek site is possible, but because of the available equipment, the Photometer would be able to read test results only for filtered results at 570 nm and 640 nm wavelengths. This limitation prevents the analysis of a wide range of chemical elements. It was therefore resolved that the sample from the black mixture froth be allowed some days in the laboratory to settle, separating the heavier particles to the bottom, and thereafter the top layer samples were analyzed. In the text, "mixture from the froth" refers to the sample taken from the top layer after settling heavier particles. While doing the test analysis, the froth mixture was filtered through a one-micron pore filter. It subjected particles that were smaller than one micron down to colloid and ionic states as viable for examination. At this point, it should be noted that characteristics of the water quality of the body, as well as the top layer of surface water downstream from the froth collector at Mimico Creek, are relatively similar.

Table 1. presents the comparison of test results between the Mimico Creek samples

Sample	Top layer of surface water downstream	Filtered mixture
Color	10	130
Iron LR	0.06	>1.00
Ammonia	0.23	16
Phostphate	0.03	0.96

Table 1 presents that the concentrations of all elements tested in the filtered froth mixture are much more elevated compared to the top layer of surface water downstream from the collector; for instance, the content of total chromium is over two times higher, and the phosphate level in the test analysis is thirty-two times

more elevated in the top layer of the surface water downstream from the collector. This validates that naturally occurring foam can effectively scavenge contaminants from the selected site at Mimico Creek.

Furthermore, the research study will be conducted year-round to ensure consistent removal outcomes for selected chemical constituents through the changing seasons. To make the frequent test analysis of numerous contaminants more feasible, we narrowed down our work to iron, ammonia, phosphate, and color. These constituents represent both inorganic and organic contaminants. The relative test result is indicated below in **Figures 1 and 2**.

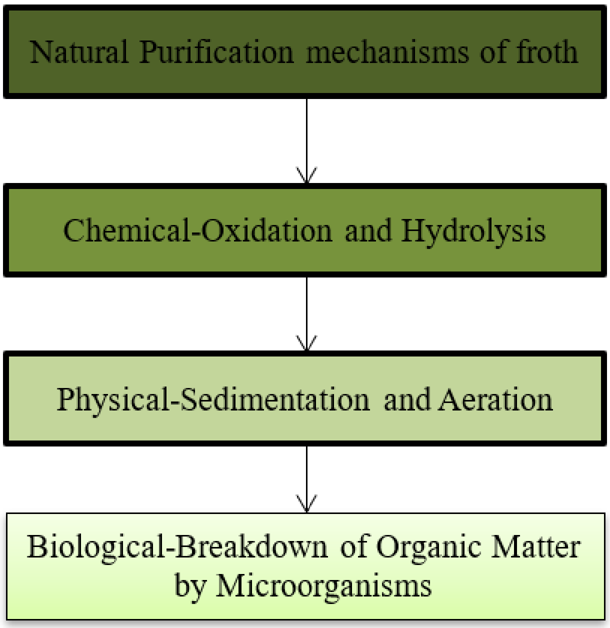

Figure 1. Natural Purification of Froth Formation

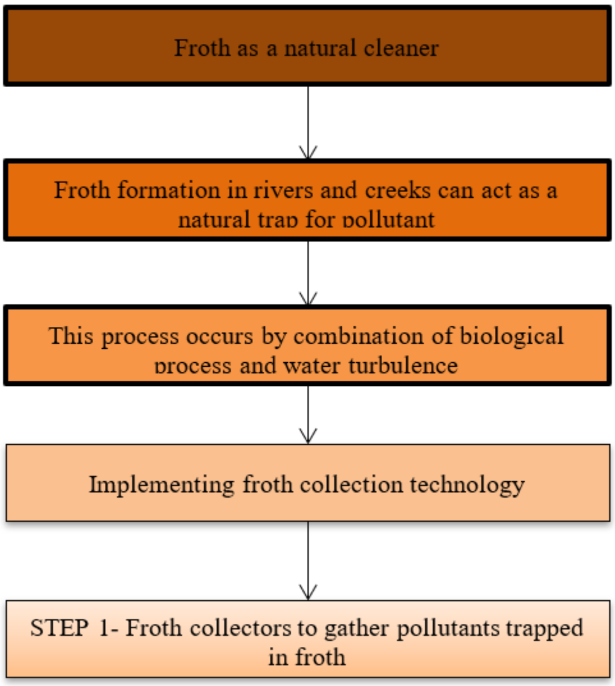

Figure 2. Froth as a Natural Cleaner

4.2. Iron

Iron is ubiquitous in natural and treated waters worldwide; therefore, its determination becomes very important in drinking water quality control and a variety of industrial processes related to, among others, corrosion control and wastewater assessment. The test results for iron in the filtered froth mixture compared with the top layer of surface water downstream from the collector are presented in **Figure 3.**

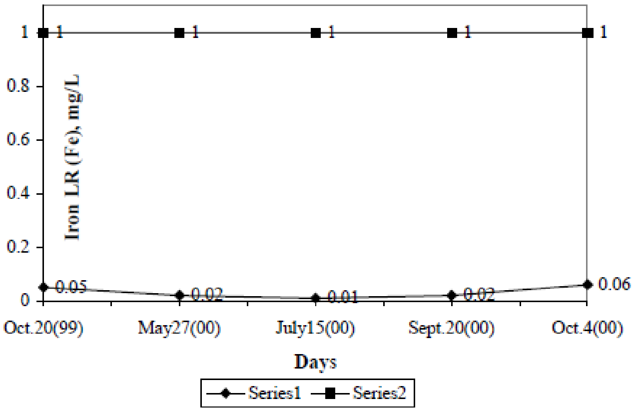

Figure 3. Comparison test results for Iron LR(Fe). (series1-Top layer of surface water downstream from collector; series2-Filtered mixture from the froth)

As seen from this figure, the iron concentration in the filtered froth mixture is appreciably higher in comparison with the surface water downstream from the froth collector during different seasons. **Figure 3** should show that all mixture concentrations of iron during the year were above the upper detection limit of the Photometer 5000 Instrument. As such, the identical concentrations of 1 mg/l shown by filtered froth mixture samples in **Figure 3** were greater than 1 mg/l (4).

4.3. Ammonia

Ammonia is formed from the decomposition of plant materials and animal matter and also from fecal matter. It is a by-product of the breakdown of urea and uric acid in urine. The wide occurrence of ammonia in fertilizers, decayed food, and sewage effluents assigns it as a highly common constituent of agricultural runoff as well as industrial wastes entering into rivers. **Figure 4** shows the comparison test results for ammonia in Mimico Creek samples.

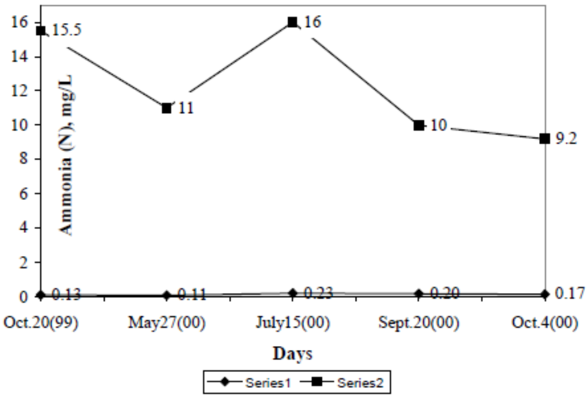

Figure 4. Comparison test results for Ammonia (N). (series1-Top layer of surface water downstream from collector; series2-Filtered mixture from the froth)

Testing of water quality, particularly phosphate testing is one such essential parameter. Though phosphates are not generally considered toxic, they do have some positive and adverse effects on the natural environment. Like phosphates also have the tendency to overgrow with aquatic plants, therefore causing an imbalance in the ecosystem. **Figure 5** Comparison test results of phosphate samples extracted at the site under study of Mimico Creek (5).

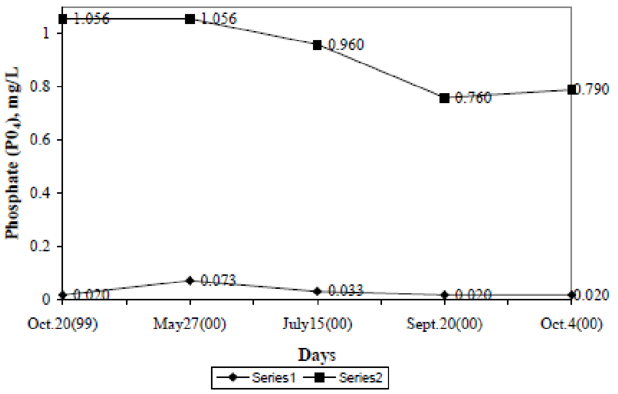

Figure 5. Comparison test results for phosphate (PO_4). (series1-Top layer of surface water downstream from collector; series2-Filtered mixture from the froth)

4.4. Color

Water color is often a good indicator of suspended and dissolved material present within the water, hence providing information on the overall organic matter in the water. In this regard, water color becomes a direct function of the concentration of the suspended or dissolved substances, which usually shows the quality of the water in that more transparent water generally is associated with better quality. The platinum/cobalt color scale, Pt/Co scale, is used to quantify the color of water samples and is equivalent to traditional "Hazen" units, which are used for visual estimation of color in water testing. **Figure 6** shows comparison testing results on creek samples for color. **Figures 3-6** show that natural froth formation works well in collecting all kinds of pollutants through the seasonal changes (8).

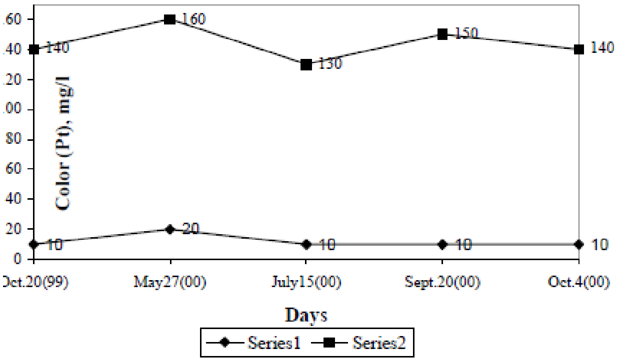

Figure 6. Comparison test results for Color (Pt). (series1-Top layer of surface water downstream from collector; series2-Filtered mixture from the froth)

Within this context, one must mention that the naturally formed froth carries pollutants in the form of suspended and heavy particles. Therefore, the test results exposed through **Figures 3-6** give only a partial notion about pollutant concentrations in the froth. However, with an overall point of view, it is exposed from the same figures and table that the concentration of pollutants in the froth itself is considerably higher than that in the top layer of surface water downstream from the froth collector.

The comparative analysis of proposed method with existing methods was illustrated in **Table 2.**

Table 2. Comparative analysis

Methodology	Research area	PO_4	Fe	N
Schilling K *et al.*	freshwater and marine ecosystems	-	9.8	-
Jaguś, A., *et al.*	The Sola River	0.06	-	-
Proposed method	Mimico Creek	0.96	>1.00	16

From the observance of **Table 2**, our proposed system remains significant results of capturing the pollutant effectively in phosphate (0.96 mg/L), nitrogen (16 mg/L) remains higher than the existing Jagus *et al.* has an phosphate of 0.06 mg/L. Jagus *et al.* shows 9.8 mg/L of iron (Fe). This comparison highlights the effectiveness of the proposed method in reducing phosphate and nitrogen levels in a specific environmental context. The efficiency of the suggested approach is higher in phosphate and nitrogen levels in a particular environmental setting are demonstrated in this comparison.

The mechanism of pollutant removal by froth formation above this is as follows: Chemical reagents such as froth and collectors are normally added to water in flotation processes. Frothers are surface-active chemicals which form a film on the surface of bubbles, frequently providing an electrical charge. Collectors are surface-active organic chemicals that also form a film on the surface of particles, and may also take on electrical charges as do froth. Froth and collectors in rivers and creeks occur by natural decomposition of amino acids, fatty acids, and other organic compounds; and by man-made pollution such as detergents and soaps (12).

Appropriate water turbulence produces extra air and biogas bubbles. These bubbles can adsorb some of the surface-active chemicals that may be present in the water and pick up an electrical charge. Similarly, on exposure to these surface-active organic chemicals, the polluting particles also pick up an electric charge. With this electric charge, the polluting particles join with the bubbles and aggregate into bubble-particle aggregates. These rise up to the surface of the stream and concentrate in the naturally formed froth. The resulting froth thus begins to contain a high concentration of pollutants, both organic and inorganic in nature. The variety of factors controlling the formation of froth on stream surfaces includes the concentrations of natural and man-made surfactants, the presence of biogas and air bubbles, and appropriate levels of turbulence (14).

The reduced concentration of heavy metals downstream from metal-forming industries may be due to the natural froth formation process that could have been proposed. In this process, biogas and air bubbles accumulate on heavy metal particles under the influence of both natural or man-made surfactants and form bubble-particle aggregates. The formed aggregates rise to the surface of the water and concentrate in the froth and what is called the thin top layer of surface water. As the current transports the froth downstream, so the bubbles forming the froth gradually collapse. Therefore, heavier aggregates settle on the riverbed, and lighter ones with fewer heavy metal particles move farther downstream. Thus, far enough away from the sources of pollution, the level of heavy metals is lower (16).

5. Discussion

Mimico Creek, Toronto, Ontario, Canada, has been a location of high interest in environmental research because of its ability to self-cleanse into froths. Efficiently concentrating pollutants downstream from areas with shallow-turbulent water conditions, the process opens up the likelihood of a potential remediation strategy for polluted water bodies. The discussion that goes forward presents the implications, advantages, challenges, and future directions related to Mimico Creek on natural froth formation in environmental remediation (1). Several environmental benefits are associated with the remediation of Mimico Creek using natural froth formation. First, reduction in nutrient concentrations through collection by froth at the top reduces the chances of eutrophication of the creek itself and to Lake Ontario, which is the receiving water body. Excessive levels of nutrients in water bodies lead to algal blooms that reduce the amount of available oxygen in the water body, making the habitat highly unbearable for aquatic systems. Such nutrients in Mimico Creek will then be captured in froth, fostering better water quality conditions.

Froth formation itself contributes to the efficient removal of pollutants from the water column, meaning that maximum fractions of pollutants, such as heavy metals, like iron and chromium, ammonia, and phosphates, are attenuated into the froth, thereby reducing their bioavailabilityğına downstream. Such reduction in toxic pollutants is hence advantageous for aquatic life, particularly by improving their habitat conditions or supporting biodiversity in the creek and associated ecosystems (1- 4). Moreover, the natural froth formation of Mimico Creek allows for the breakup of oil products floating on the surface of the water. This could be vital in improving aquatic habitat and preventing direct harm to wildlife that may reside or rely on the creek and associated wetlands. Several key mechanisms are involved in the process of the natural formation of froth on Mimico Creek. Water cascading over weirs and other obstacles creates turbulence, which induces the formation of air and biogas bubbles. Those bubbles combined with natural and man-made surfactants present in the water adhere to such pollutants as heavy metal particles and organic contamination. These formed bubble-particle aggregates rise to the water surface and accumulate as froth (5- 9).

Such froth acts as some sort of concentrated layer for pollutants, which can, in turn, be picked up using froth collectors sites downstream of turbulent areas. These collectors have been designed to trap the froth without hindering the natural flow of water or the traveling of aquatic organisms underneath. Froth collected can be analyzed to monitor pollutant concentrations and effectiveness in pollutant removal. While potential definitely exists within the natural froth formation approach, there are also a number of challenges and considerations. First, there will be seasonal variability depending on changeable water flows, turbulence, and pollution loading in general. This demand constant monitoring with adaptability to management strategies brings out the remediation process at its best at any time of the year (11- 16). While froth is a great way to capture a very wide range of pollutants, whether they be organic or inorganic contaminants, its collection and subsequent disposal need to be handled with great care to avoid secondary pollution or damage to the environment. Proper methods should be put in place with respect to its disposal so that the pollutants, after being captured by the froth, do not get back into the environment to cause risks to both human and animal life (17). Furthermore, froth formation may also be limited to specific pollutant types or even environmental conditions. This may be because of factors such as natural surfactant availability, the morphology of the watercourse, which induces turbulence, or the general health of the ecosystem itself at one location or another (18). There are several areas that need to be looked into in future studies on self-organizing natural froths in Mimico Creek and similar environments. First, long-term monitoring should be conducted in assessing the sustainability or, rather, resilience of the remediation strategies based on froth over long periods. Understanding how the process of froth formation varies with changes in climate, land use, and water quality will help inform adaptive management practices (20).

Further studies are needed to elucidate precisely the mechanisms involved in pollutant attachment to bubbles and their aggregated froth. Laboratory tests must be conducted on the role of various surfactants, particle size distribution parameters, and water chemistry variables on the froth formation processes. These insights could help tailor froth collectors better for improved rates of pollutant removal (21). Finally, comparative studies at different streams, flows, and environments can further develop the current understanding of the applicability of froth formation as a natural remediation technique. In Windermere, investigating the variation in froth composition, pollutant uptake rates, and ecological impacts will add to best practice and possible limitations of this approach on a broader scale (19).

In summary, the natural process of froth formation in Mimico Creek represents a very promising approach to the remediation of polluted water bodies. With natural processes of turbulence, interaction of surfactants, and pollutant aggregation, Mimico Creek cleanses itself quite effectively. The approach brings about a reduction in nutrient loads, toxins, oil contaminants, and all other types of pollutants, while increasing biodiversity and the health of the ecosystem (22). In the future, both research and application of froth formation in environmental remediation should advance hand-in-hand with the concerns that emanate from adaptive management through interdisciplinary collaboration to participatory consulting (23). Tapping into the natural resilience of Mimico Creek and similar ecosystems will make it possible for us to help forge sustainable solutions to water pollution events and for the betterment of human and environmental health in urban and natural landscapes alike.

6. Conclusion

In this regard, we further evaluated this inherent froth formation process at the selected site of Mimico Creek and demonstrated that naturally developed froth at this location has higher pollutant concentrations compared to the top layer of surface water downstream from the installed froth collector. Much of these pollutants are trapped by the froth, including the organic matter, heavy metals like iron and chromium, and substances like ammonia, phosphate, and nitrate from the polluted site of the creek. Thus, our hypothesis Mimico Creek has inherent potential to self-clean through froth formation has been substantiated. Therefore, tapping into the natural biological, chemical and physical self-purification mechanisms directly gives an in-situ treatment methodology to restore heavily contaminated creeks who by definition non-point source pollution affected creeks. Following are some of the benefits that can be identified in connection with the restoration of Mimico Creek: Nutrient reduction and associated algae population reductions in the Creek and its discharge to Lake Ontario, Toxin reductions in Mimico Creek and Lake Ontario, Eliminate oil products that float on the water surface of the creek to make it more habitable for other aquatic species.

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