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ARTICLE

Application of Diatomaceous Earth for Fecal Coliform Reduction in Sediments and Its Agricultural Benefits

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ABSTRACT

This study highlights the potential of diatomaceous earth to eliminate pathogenic microorganisms from canal sediments used in agricultural irrigation. The findings demonstrate both technical feasibility and economic benefits for agriculture, particularly in regions where such irrigation practices are common. The research incorporates three distinct projects. The first involved monitoring water and sediment quality in the Xochimilco canal zone in Mexico City. The other two were experimental studies aimed at assessing the efficacy of diatomaceous earth in reducing fecal coliforms in sediments. The first project evaluated the water and sediment quality. Subsequently, an experiment was conducted in the San Gregorio Atlapulco chinampa, where diatomaceous earth was applied to a coriander crop to measure its effectiveness in reducing fecal coliforms. A laboratory experiment at the Institute of Engineering, UNAM, tested the impact of diatomaceous earth on sediments from a Xochimilco canal, focusing on fecal coliform reduction. In all experiments, diatomaceous earth was utilized in its commercial form. The results of the first project identified wastewater discharges as the primary source of pathogenic contamination in the canals. The second demonstrated a significant reduction—over 70%—in fecal coliforms within a crop after the application of diatomaceous earth. Similarly, the third project achieved an average fecal coliform reduction of 70% in sediments during laboratory testing. The study underscores the affordability and accessibility of diatomaceous earth for local agricultural producers. Moreover, its application does not adversely affect soil quality or crop productivity, further supporting its viability as a sustainable solution for improving irrigation water quality.

Keywords: Diatoms; Fecal Coliforms; Crop; Chinampa; Xochimilco

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1. Introduction

Xochimilco, located in Mexico City, is the last remnant of the peoples of the lake basin in the pre-Hispanic world, where today a system of cultivation of the land called chinampa is still used, where the sediments of the canals are used as a base to deposit the seeds of vegetables and other types of crops. The existence of these canals and the chinampas led to the recognition of this área, in 1987, as a Cultural Heritage of Humanity by UNESCO [1]. However, at present, the area is inhabited by an irregular population that discharges wastewater directly into the canals, so the sediments for the crops contain concentrations of fecal coliforms above the normativity, which implies a risk to the health of the local population as well as to the consumers of the crops [2, 3].

In many countries, irrigation water contains similar conditions and that is why it is of interest, in this study, to test diatomaceous earth as a factor for the elimination of coliforms with an effective and low-cost product.

The Xochimilco canal system, declared a cultural heritage of humanity by UNESCO in 1987, faces severe environmental challenges. One of the most pressing issues is the poor quality of its water, largely attributed to the discharge of untreated domestic wastewater directly into the canals, as evidenced by water and sediment monitoring carried out in 2014 [2].

The use of surface water for agricultural irrigation in Latin America is deeply influenced by climatic conditions, the availability of water sources, and irrigation infrastructure.

In Argentina, agricultural irrigation in arid provinces such as Mendoza and San Juan depends on rivers, particularly the Mendoza River. The network of irrigation canals and reservoirs is a key source for agricultural irrigation, especially for crops like grapes and fruit trees [4]. Chile uses large reservoirs and rivers for agriculture, particularly in the Central Valley, where the country's most important crops, such as vineyards, are located [5]. In Brazil, especially in the Northeast region, the use of surface water for agricultural irrigation is common, with rivers like the São Francisco serving as a key source. This river and its tributaries supply large agricultural areas in semi-arid regions [6]. In Peru, the use of surface water for agricultural irrigation is concentrated in coastal valleys, such as the Ica Valley, which rely on the region's rivers [7].

The discharge of untreated domestic wastewater into European rivers represents a significant concern for public health and the environment. Below are some of the rivers most affected by this issue.

Most of the water used for irrigation in Spain comes from surface sources, such as rivers and reservoirs. It is estimated that 74% of the water used for agricultural irrigation is of surface origin. In Spain, fecal contamination affects several rivers. The Ebro River has experienced a decrease in water quality due to agricultural pollution. Additionally, the Júcar River has been contaminated by periodic discharges of sewage from various municipalities due to the lack of treatment in its waters [8].

In Portugal, fecal contamination in rivers is a significant concern. Domestic pollution generates a high health risk due to the high concentrations of fecal microorganisms that can be found. The main source of water for irrigation in Portugal is surface water from rivers, especially large rivers such as the Tagus, Douro, Guadiana, and Minho. These rivers provide water to the country's main agricultural areas [9]. The presence of fecal contamination indicators, such as fecal coliforms and *Escherichia coli*, has been documented in various river basins.

Rivers and reservoirs are the main sources of water for irrigation in Italy. For example, the Po River and its tributaries supply water to the agricultural regions of northern Italy. Domestic pollution generates a high health risk due to the high concentrations of fecal microorganisms that can be found. Although Paris has a wastewater treatment system, untreated wastewater discharges have occasionally occurred due to intense rains that exceed the capacity of the treatment plants [10].

Fecal contamination in the rivers of Europe, Latin America, as well as in Asia and Africa, represents a significant challenge for public health and environmental sustainability [11–15].

In vegetable agriculture, diatomaceous earth is applied as both a soil amendment and a nutrient enhancer. In addition to its pesticide effects, it supplies large quantities of minerals and nutrients [16], which are vital for plant growth but often absent in poor or depleted soils. These minerals penetrate plant plasma and circulate through its sap [17, 18].

Diatoms are the primary food source for fish and other marine organisms [19]. They are unicellular eukaryotic microorganisms, with protoplasts containing the same organelles as other eukaryotic algae [20]. Diatoms are found in plankton and benthos across oceanic, coastal, and freshwater habitats and are abundant in certain humid terrestrial environments [21]. Their silica-impregnated cell walls, called frustules, consist of two units known as leaflets [22]. Diatoms range in size from less than 5 microns to 100 microns, and their specific morphologies feature internal pores smaller than 0.1 microns [23, 24]. The frustule's structure can be hexagonal, rod-like, or circular, with each species exhibiting distinct surface areas.

Based on their shape, diatoms are classified as centric (radially symmetrical) or pinnate (elongated). These features, along with well-organized pores and specialized structures, make diatoms highly valued in various applications [25]. **Figure 1** illustrates the diversity of diatom forms.

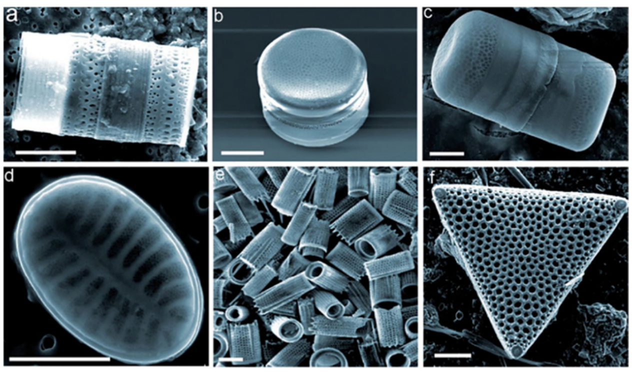

Figure 1. Diversity of diatom forms [26].

Diatomite, a pale, soft, lightweight sedimentary rock, is composed primarily of silica microfossils from aquatic single-celled algae. The amorphous silica forming the frustules is the primary constituent, alongside metal oxides, clays, and organic matter [27, 28]. Frustules are composed of silicic acid ($Si(OH)_4$), and upon diatom death, these sink and accumulate at the bottom of aquatic environments as diatomite deposits [19]. The characteristics of diatomite include very low density, high porosity, and high specific surface area, which confer a high adsorption capacity.

Diatomite is formed from the remains of diatoms deposited in seas or lakes. It is used in various applications, including reinforcement, stiffening, and hardening of organic solids, reducing adhesion between surfaces, increasing viscosity, and as a surfactant, hydrophobic agent, absorbent, catalyst, and for cloud seeding [29]. The unique physical properties of diatomaceous earth, such as high permeability (0.1–10 m per day), porosity (35–65%), low density, and low thermal conductivity, make it beneficial for industrial uses like filtration and adsorption of organic and inorganic chemicals, as well as for oil spill management [30].

Although silica is the main component of diatomite, varying amounts of impurities, such as metal oxides, clays, salts (mainly carbonates), and organic matter, may be present. Environmental conditions, chemical precipitation, and atmospheric exposure influence the impurity content [19]. Thus, purification processes are necessary to obtain diatomaceous earth in the form of silica microshells [31].

Various methods exist to modify the surface characteristics of diatoms for specific purposes. Hydrochloric acid purification and calcination make diatoms more inert for use as filter supports. However, the removal of hydroxyl groups reduces adsorption capacity. Treatments with NaOH and MnO have been employed to enhance adsorption for heavy metal removal (e.g., Pb^{2+}, Cu^{2+}, and Cd^{2+}) from wastewater [31]. Additionally, diatomite modified with lime and aluminum sulfate has been used to remove phosphorus from wastewater [32].

Diatoms have also inspired the development of nanoscale biomaterials. They can be modified to incorporate nanoparticles or biomolecules, leveraging their mechanical strength, high surface area, and porous three- and nanodimensional structures to create advanced functional materials [33].

The adsorption and filtration capabilities of diatomaceous earth have been extensively tested for wastewater treatment, especially for heavy metal removal [34–40]. However, the mechanisms of adsorption remain unclear, and its application for removing fecal coliforms has not been documented. Additionally, limited research exists on the use of diatoms in contaminated soils or sediments [31], particularly regarding sediment-bacteria associations such as fecal coliforms.

Bacteria are often found in sediments of water bodies, where they adhere to suspended solids, increasing sedimentation. The reduction of fecal coliforms may result from unfavorable environmental conditions like temperature, humidity, and oxygen [41]. In Xochimilco, canal sediments are commonly used as substrates for crops in chinampas. However, these sediments often harbor pathogenic microorganisms that contaminate crops.

Scientific Gap: While diatomaceous earth has shown effectiveness in adsorbing heavy metals, its potential for removing fecal coliforms from sediments remains unexplored. Furthermore, the sediment-bacteria association, particularly for pathogenic microorganisms, is not fully understood.

Hypothesis: Adding diatomaceous earth to sediments in water bodies containing pathogenic microorganisms can reduce and potentially eliminate fecal coliforms.

Objective: This study aims to monitor water and sediment quality in the Xochimilco canal zone and evaluate the effectiveness of diatoms in removing fecal coliforms from sediments.

2. Methodology

The methodology of this work considers three projects: the first is the basis of the experimental projects and involves the monitoring of water and sediments of the canal zone that covered more than 200 km of sampling in 6 canal zones. The second project takes into account the results of the monitoring and since the parameter of fecal coliforms stands out for its high values that do not comply with the regulations [42], this point is addressed with the proposal of the use of diatomaceous earth to reduce and eliminate the presence of fecal coliforms. The second project is carried out in a chinampa in which the traditional form of cultivation is followed and a portion of the land is divided based on an experimental design that involves the addition of diatomaceous earth on top of the sediments. The third project has the same objective of measuring the decrease in the population of fecal coliforms by adding diatomaceous earth in sediments of one of the channels previously monitored. In this case, the experimentation is carried out in the laboratory.

2.1. Water and Sediment Monitoring in Canal Areas

A comprehensive monitoring of the canal area was conducted to identify the distribution and common types of pollutants in different zones, prior to the experimental projects.

Sampling involved 100 points across six designated zones, encompassing both water and sediment samples: Tourist zone (T), Caltongo zone (ZC), National Canal zone (N), San Gregorio Atlapulco zone (SG), San Luis Tlaxialtemalco zone (SL), Ejido de San Gregorio zone (ESG).

In each area, between 10 and 12 sampling points were considered and in each site water and sediment samples were taken considering the following parameters:

For water: BOD, total nitrogen (Ntot), nitrites (NO_2), nitrates (NO_3), Kjeldahl nitrogen (NKj), total phosphorus (Ptot), total suspended solids (TSS), fats and oils (GyA), detergents (SAAM). Metals: cadmium (Cd), boron (B), iron (Fe), chromium (Cr), manganese (Mn), lead (Pb), zinc (Zn). Organophosphate and organochlorine pesticides. Microorganisms: fecal coliforms, enterococci and helminth eggs.

For sediment: organic matter, nitrates (NO_3), phosphates (PO_4). Metals: boron, iron, cadmium, chromium, manganese, lead, zinc. Microorganisms: fecal coliforms, enterococci, helminth eggs. **Figure 2** shows the sampling points.

Before starting the experimentation with diatomaceous earth in sediments, three types were analyzed using diffractograms (EMPYREAN diffractometer, located at the Institute of Materials of the UNAM). The mineralogy results are shown in **Table 1**.

Table 1. Mineralogy of diatomaceous earths analyzed.

Type of Diatomaceous Earth	Composition
Filter Cel	Opal type A (>95%) Tridymite: SIO_2 tracers
JT Baker	Christobalite: SiO_2 (64%) Tridymite: SiO_2 (36%)
Celite Hycel	Christobalite: SiO_2 (80%) Tridymite: SiO_2 (20%)

Due to the similarity of the composition of the three types of diatoms analyzed, it was decided to use Celite Hycel due to its low cost and easy acquisition. **Figure 3** shows an electron microscope image.

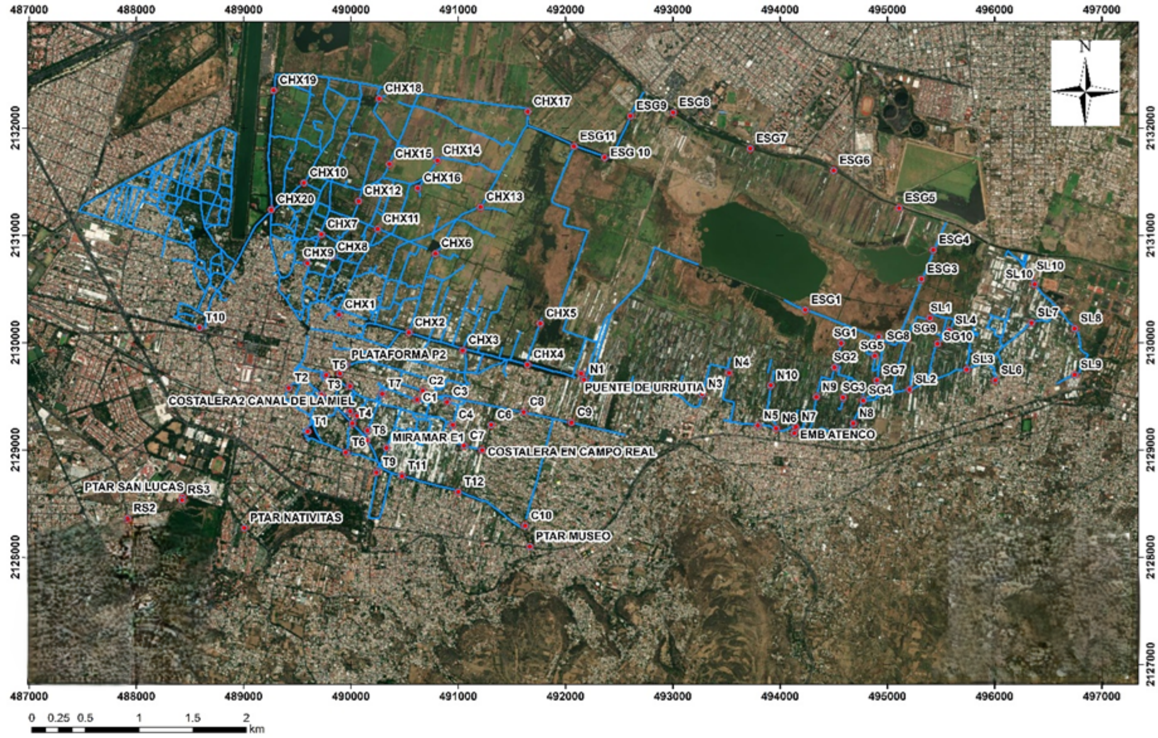

Figure 2. Sampling points in the canal zone of Xochimilco.

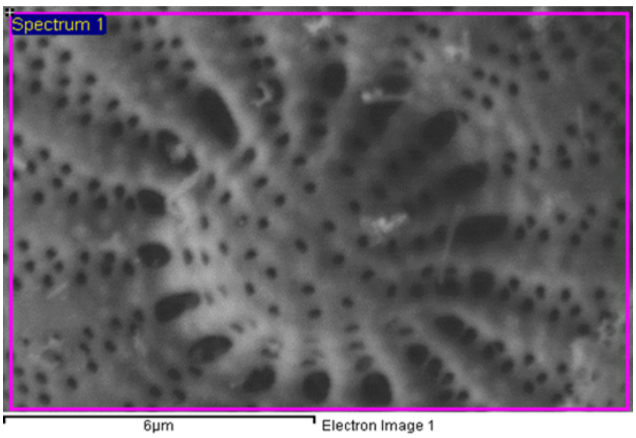

Figure 3. Celite Hycel diatomaceous earth electron microscope image.

2.2. Experiment in a Chinampa in the Ejido of San Gregorio

With the knowledge of the analyzed sediments, the experiment began in a chinampa to test the efficiency of diatoms in the reduction of coliforms. The experimental area (UTM coordinates 14Q 0494768 and 2129547) with 9 m long and 5.5 m wide was covered with sediments from the bottom of the adjacent canal, as it is customary to prepare all the chinampas in Xochimilco. It was divided into seven parts with the distribution shown in **Figures 4** and **5**.

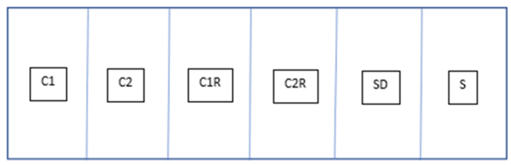

Figure 4. Experimental area in chinampa.

Note: C1 and C2; coriander and addition of dry diatoms to the soil and crop; C1R and C2R: coriander with addition of diatoms and irrigation; SD: soil with added diatoms (without coriander); S: area with soil only.

Figure 5. Experimental area with application of diatoms.

The coriander (Coriandrum sativum) was planted a week after the area was prepared in ST, and C1 to C4. Diatoms were added in plots C1, C2, CR1, CR2 and SC with the respective irrigation, which was repeated once a week. A week later, samples were obtained from each area and diatoms were again added in C1, C2, CR1, CR2 and SD.

This was repeated every week until the coriander cycle was completed and it could be harvested (10 weeks). Irrigation in CR1 and CR2 was weekly. Sediment samples were obtained at the middle of the cycle and at the end of it.

2.3. Laboratory Experiment with the Application of Diatoms in Sediments of a Canal in Xochimilco

Sediments for this experiment were collected from a canal adjacent to the chinampa used in a prior study. The sediments were left exposed to the environment for 48 hours to reduce excess moisture before the experiment commenced. The testing involved 15 aluminum containers filled with 500 g of sediment each, where the effect of Celite Hycel diatomaceous earth was evaluated under two concentration levels: 50 g kg^{-1} and 100 g kg^{-1}.

Two treatment modalities were implemented: one in which diatomaceous earth was mixed with the sediments every 48 hours and another in which no mixing occurred. The experimental design included triplicates for each treatment combination and three control containers with untreated sediments, resulting in a total of 15 containers. The experimental design can be summarized as follows:

- 1 type of diatomaceous earth × 2 concentrations × 2 mixing modalities × 3 replicates = 12 test containers
- 3 control containers with untreated sediments for baseline comparison.

The idea of considering mixing as a variable in the design of the experiment is that in the bioremediation of contaminated soils, it is mixed with various methods in order to oxygenate the environment and promote biodegradation.

Sampling was conducted biweekly, with one sample collected from each triplicate group over five intervals, ensuring robust data collection throughout the study. The setup, shown in **Table 2** and **Figure 6**, illustrates the arrangement and treatment conditions.

Table 2. Experiment design.

Tray	Mixing	Concentrations
CH1 CH2 CH3	Diatoms were mixed with sediments	Addition of 50 g of diatoms. (10%)
CH4 CH5 CH6	Diatoms added to sediments. Unmixed	
CH7 CH8 CH9	Diatoms were mixed with sediments	Addition of 25 g of diatoms. (5%)
CH10 CH11 CH12	Diatoms added to the sediments. Unmixed	
CH13 CH14 CH15	Test targets	

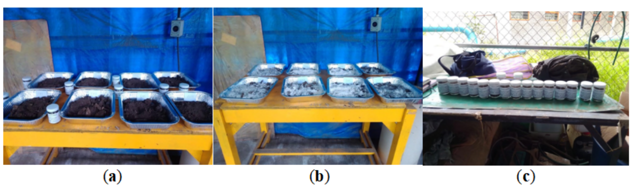

Figure 6. (**a**) Trays with homogenized sediments; (**b**) sediments plus diatoms; (**c**) samples.

This experiment was structured to systematically assess the effectiveness of diatomaceous earth in reducing fecal coliforms under varying conditions of concentration and sediment mixing. Results are expected to contribute to understanding the optimal application parameters for diatomaceous earth in improving sediment quality.

3. Results

3.1. Water Quality and Sediments of Canals

In the project to monitor water and sediments in more than 200 km of canals, results were obtained for six areas, with more than 100 sampling points. In this work, the results are only presented for one of the zones for reasons of space, but the results for all the zones are similar. **Tables 3** and **4** present the results of the samples from the tourist area, which was selected for this work, for water and sediments, respectively. **Figures 7** and **8** present the respective images of fecal coliforms concentrations in sediments, which is the most representative parameter of poor sediment quality; both show the excess of fecal coliforms in the canal zone with respect to the concentrations permitted in the corresponding standard[42].

Table 3. Physic, chemical and biological analyses in the tourist area, in water.

Parameter mg l^{-1}	T1	T2	T3	T4	T5	T6	T8	T9	T11	T12
Organic matter (%)	13.5	ND	19.7	20.7	ND	19.9	19.9	12.6	34.1	18.4
NO3	1.96	1.88	2.85	1.19	1.46	1.15	1.57	2.99	3.07	2.10
P	2453	2445	1483	3200	4353	1598	1136	1090	2467	1133
B	30.94	NR	NR	32.91	NR	31.38	NR	23.09	29.28	NR
Cr	36.94	NR	NR	55.36	NR	55.1	NR	49.45	31.68	NR
Mn	153.7	246.1	NR	120.8	248.9	112.7	NR	76.01	98.08	NR
Pb	58	NR	NR	89.85	NR	92.11	NR	82.49	54.93	NR
Zn	171.1	NR	NR	280.8	NR	293.1	NR	278	567.7	NR
Coliform (fecals) MPN g^{-1}	2668	5305	896	ND	ND	850	1395	2778	62935	19291
Enterococci	320	NR	156	ND	NR	148	227	269	ND	965
Helminth eggs	NR	NR	NR	0	NR	NR	NR	NR	NR	0

Note: MPN: more probable number; ND: non detected; NR: non done.

Table 4. Physic, chemical and biological analyses in the tourist area in sediments.

Parameter (mg kg^{-1})	T1	T2	T3	T4	T5	T6	T8	T9	T10	T11	T12
DBO total	22	15	11	7	7	23	7	8	7	18	8
G y A	ND	ND	ND	ND	NR	NR	NR	NR	NR	NR	ND
SST	42	24	25	16	13.5	30	15	17	14	28	12
SAAM	NR	NR	NR	NR	NR	NR	0.116	NR	NR	NR	0.641
N total	7.63	8.37	9.34	10.76	8.33	10.4	11.51	12.61	8.91	8.73	4.86
NO2	0.066	0.175	0.682	0.689	0.524	0.628	0.756	0.924	0.787	0.088	0.430
NO3	0.062	0.081	3.222	6.211	4.818	2.334	7.980	7.714	5.934	0.065	0.187
N Kjeldahl	7.50	8.11	5.44	3.86	2.99	7.44	2.77	3.97	2.19	8.58	4.25
P	2.65	2.68	2.18	1.82	ND	2.51	1.58	1.72	1.75	2.82	1.75
B	0.29	0.31	NR	0.73	0.38	0.21	NR	0.73	0.48	0.59	0.56
Cr	ND	ND	NR	ND	ND	ND	NR	ND	ND	ND	ND
Mn	0.07	0.082	NR	0.079	0.045	0.033	NR	0.07	0.053	0.114	0.123
Pb	ND	NR	NR	ND	ND	ND	NR	ND	ND	ND	ND
Zn	0.049	0.035	NR	0.021	0.015	0.016	NR	0.045	0.02	0.050	0.034
Organophosphate pesticides	NR	ND	ND	ND	ND	ND	NR	ND	ND	ND	NR
Organochlorhate	NR	ND	ND	ND	ND	ND	NR	ND	ND	ND	NR
Coliform (fecals) MPN per 100 ml	>24000	>24000	>24000	4600	>24000	>24000	11000	>24000	930	>24000	<24000

Note: ND: non detected ; NR: non done; MNP: more probable number.

Mexican regulations[41] establish a maximum amount of fecal coliforms of 240 per 100 ml for reuse of treated water in public services. In the monitored channels this value is exceeded more than 100 times. According to the results of fecal coliforms in the canal zone, it was decided to propose experimentation with the sediments of the canals since they are the ones used as a base for crops in the chinampas.

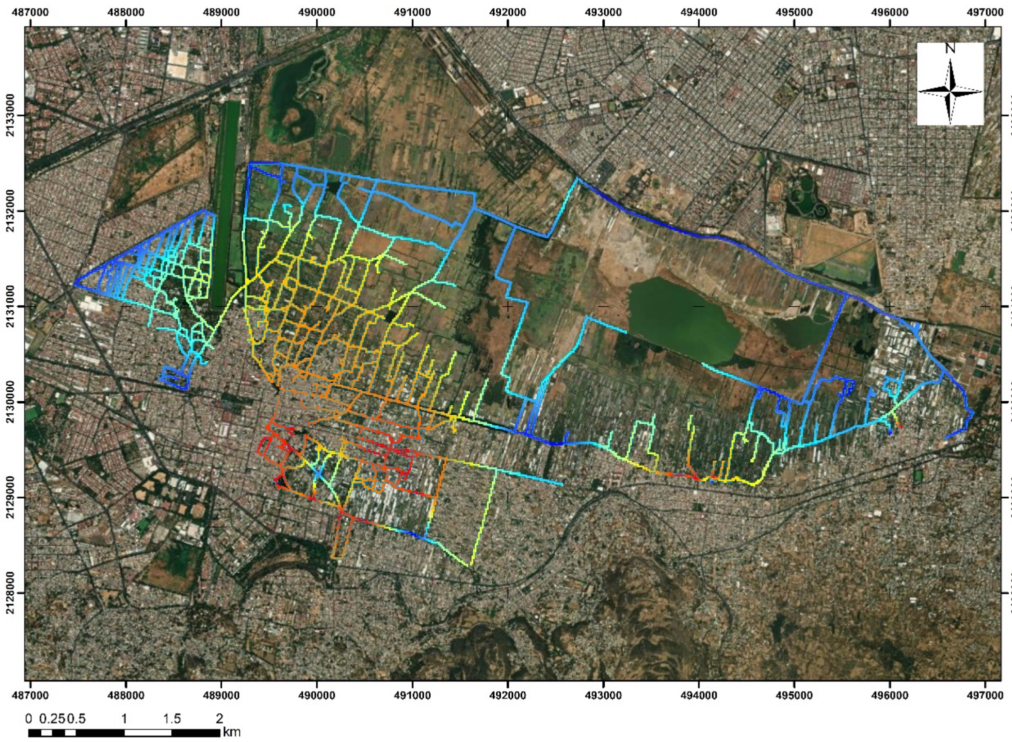

Figure 7. Fecal coliforms in water in canal zone based on NOM-003-ECOL-1997.

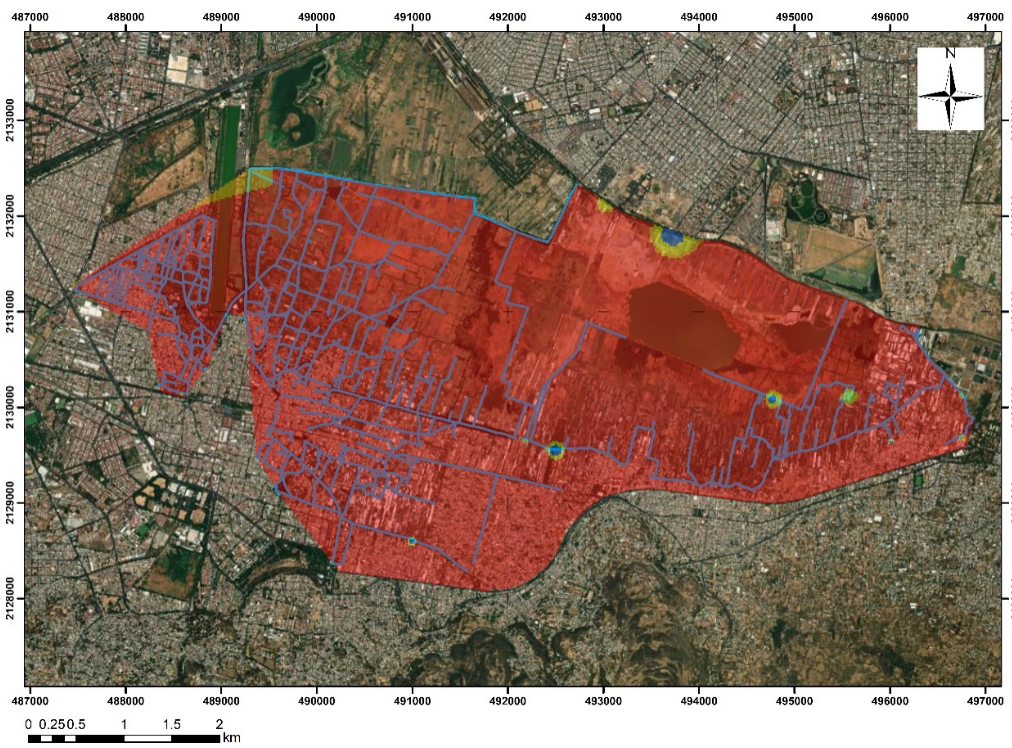

Figure 8. Red zone indicates that the regulations are exceeded.

3.2. Results of the Experiment in Chinampa

Table 5 shows the initial concentrations of fecal coliforms in sediments of the experimental site, in each of its divisions, and **Table 6** shows the same parameter for second and third sampling.

Figure 9 shows the removal of fecal coliforms in the

Table 5. Concentrations of initial fecal coliforms in the soil of the chinampa.

Sample	Concentration Fecal Coliforms CFU g^{-1}
C1	56000000
C2	56000000
C1R	67000000
C2R	63000000
SD	64000000
S	75000000
ST	NR

Note: CFU: Colony forming units; NR: non done.

Table 6. Fecal coliforms in soil in the second and third sampling.

Sample	Concentration Fecal Coliforms Sampling 2 CFU g^{-1}	Concentration Fecal Coliforms Sampling 3 CFU g^{-1}
C1	20000	0
C2	25000	0
C1R	60000	8000
C2R	55000	7500
SD	63000	45000
S	75000	56000

Note: CFU: colony forming units; Sampling 2: after 5 weeks. Sampling 3: after 10 weeks at the end of the experiment.

third sampling compared to the second. It also shows that in the samples in which water from the canal was not added, there are lower concentrations of fecal coliforms and also that in the S (only soil) the removal of coliforms is lower. The graphic with soil with SD diatoms shows a considerable decrease in the third sampling, probably due to the fact there was no crop where the CF developed.

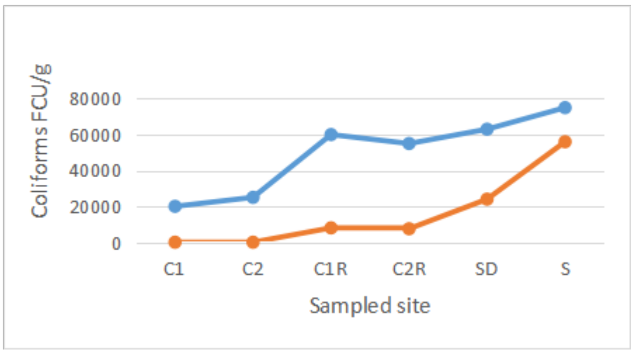

Figure 9. Fecal coliforms in samples 2 and 3.

3.3. Results of the Experimental Laboratory with Application of Diatoms in Sediments

Table 7 presents the initial concentrations of fecal coliforms in the experimental units with sediments and application of Celite Hycel diatomaceous earth. **Table 8** shows the concentration after the experiment.

4. Discussion

The experiments conducted in the Xochimilco canal zone demonstrate the potential of diatomaceous earth for the reduction of fecal coliforms in contaminated sediments. Removal rates of 70% to 80% were achieved across various experimental conditions. While these results did not meet the regulatory standards for permissible fecal coliform levels, this limitation is attributed to the relatively short treatment duration applied in this study. It is anticipated that extended application periods, under practical field conditions, will achieve further reductions, potentially complying with regulatory thresholds.

The study highlights the use of Celite Hycel diatomaceous earth as a practical and cost-effective treatment method. Its inert properties ensure it does not negatively affect the soil's pH or chemical composition, making it highly suitable for agricultural applications. In the San Gregorio Atlapulco chinampa, the experiment demonstrated that diatomaceous earth significantly reduces fecal coliform levels, particularly when compared to untreated sediments irrigated with canal water. Moreover, the laboratory experiments conducted at the Institute of Engineering, UNAM, further validated these findings, showing consistent results under controlled conditions.

Table 7. Initial concentrations.

Name	CF (MLN g^{-1})	Concentration (g diatoms g^{-1} sediment)	Name	CF (MLN g^{-1})	Concentration (g diatoms g^{-1} sediment)
CH1	430000	0.1	CH7	230000	0.05
CH2	430000	0.1	CH8	230000	0.05
CH3	430000	0.1	CH9	230000	0.05
CH4	430000	0.1	CH10	93000	0.05
CH5	430000	0.1	CH11	93000	0.05
CH6	430000	0.1	CH12	93000	0.05
			CH13	430000	0
			CH14	430000	0
			CH15	430000	0

Note: MLN: most likely number.

Table 8. Initial and final concentrations of fecal coliforms FC.

Name	Initial Concentrations FC (MLN g^{-1})	Final Concentrations FC (MLN g^{-1})	Removal Efficiency (%)
CH1	430 000	230 000	46
CH2	430 000	43 000	90
CH3	430 000	23 000	94
CH4	430 000	93 000	78
CH5	430 000	43 000	90
CH6	430 000	NR	
CH7	230 000	43 000	81
CH8	230 000	39 000	83
CH9	230 000	15 000	93
CH10	93 000	23 000	75
CH11	93 000	75 000	19
CH12	93 000	NR	
CH13	430 000	230 000	46
CH14	430 000	93 000	78
CH15	430 000	430 000	0

Note: MLN: most likely number.

Adsorption mechanisms likely play a critical role in the reduction of fecal coliforms, where weak Van der Waals forces facilitate the attachment of coliforms to sediment particles, overcoming repulsive forces. Additionally, environmental factors such as temperature, oxygen, and humidity also contribute to the decline in fecal coliform populations during treatment. This study also underscores the importance of further exploring the interaction between sediments and bacterial communities to optimize the use of diatomaceous earth for sediment remediation.

The literature recommends analyzing metals in sediments due to the inhibition of bacterial activity that they can produce[43]; in this case, its analysis was not done due to the low values obtained in the monitoring of water and sediments in the Canal Zone. There is little information on studies in soil or sediment for the removal of organic contaminants with diatomites. Studies of the sediment/bacteria association, in this case fecal coliforms, have not been fully understood[44].

Despite minor inconsistencies in some experimental results, the overall findings confirm that diatomaceous earth offers significant potential for improving sediment quality in the Xochimilco canal system. Its low cost, accessibility, and ease of application further enhance its appeal for use in agricultural irrigation systems in areas like Xochimilco, where water contamination remains a pressing issue.

5. Conclusions

In Mexico, as in many countries with large areas affected by water scarcity, excessive use of fertilizers for crop irrigation leads to adverse effects, including physical and chemical changes in the soil, deterioration of groundwater, and negative impacts on crop productivity. The use of diatomaceous earth, being an inert material, contributes silica that is harmless to the soil's natural microorganisms. This represents an opportunity for the agricultural economy since the cost of diatomaceous earth is significantly lower than that of fertilizers. Furthermore, it enhances plant growth by reducing pests in both crops and soil.

This study highlights the reduction of fecal coliforms in the sediments of a chinampa, a traditional cultivation system dating back over 500 years. While chinampas are now rarely used, the application of diatomaceous earth is not limited to this system. It is equally effective in irrigated crops that utilize treated water, rainwater, or surface water from reservoirs, rivers, and lakes, all of which may contain pathogenic microorganisms.

Diatomaceous earth offers multiple advantages, including affordability, accessibility, and its dual role as a microbial reducer and soil conditioner. This makes it a sustainable and efficient alternative for improving irrigation water quality and enhancing agricultural productivity, particularly in regions facing challenges with untreated irrigation water.

Author Contributions

In this work, R.I. designed the monitoring of the water and sediments of the Xochimilco canals and designed the experiment in the laboratory. A.C. designed the experiment in the field. Both supervised all the experiments and the results.

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Institutional Review Board Statement

Not aplicable due to not human or animal testing.

Informed Consent Statement

Not applicable, the study did not involve humans.

Data Availability Statement

The data used for the study are available upon request from the author.

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Conflict of Interest

All authors disclosed no conflict of interest.

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