

# Lack of Sanitation: Algae Ponds for Wastewater Treatment in Remote and Rural Areas

Bruno Ibarra and Ramiro Acosta

*Civil Engineering Department, Universidad Tecnológica Nacional, Facultad Regional Paraná  
1033 Almafuerte Av, Paraná, Entre Ríos, Argentina*

brunoibarra@alu.frp.utn.edu.ar

ramiroacosta@alu.frp.utn.edu.ar

**Abstract**— Millions of people around the world do not have decent access to sanitation to meet their basic hygiene and health needs, leading to disease and thousands of deaths per year. The objective of this work is to address wastewater treatment for domestic or agriculture uses and sanitation installations in rural areas so that the inhabitants of these communities have a better quality of life. To achieve this aim, this work addresses the problem, causes and consequences of lack of sanitation in rural and remote areas of cities. Secondly, a system of algae ponds to treat wastewater will be presented. Finally, an analysis is made of the benefits and disadvantages that may arise from the proposed solution. It is expected that this paper may promote the implementation of alternative and sustainable methods for wastewater treatment.

**Keywords:** water scarcity, sanitation, wastewater, algae ponds

**Resumen**— Millones de personas en todo el mundo no tienen acceso decente al saneamiento para satisfacer sus necesidades básicas de higiene y salud, lo que provoca enfermedades y miles de muertes al año. El objetivo de este trabajo es abordar el tratamiento de aguas residuales para usos domésticos o agrícolas e instalaciones de saneamiento en zonas rurales para que los habitantes de estas comunidades tengan una mejor calidad de vida. Para lograr este objetivo, este proyecto aborda el problema, las causas y las consecuencias de la falta de saneamiento en las zonas rurales y remotas de las ciudades. En segundo lugar, se presenta un sistema de estanques de algas para tratar las aguas residuales. Por último, se analizan los beneficios y desventajas que pueden derivarse de la solución propuesta. Se espera que este documento pueda promover la aplicación de métodos alternativos y sostenibles para el tratamiento de las aguas residuales.

**Palabras clave:** escasez de agua, saneamientos, aguas residuales, estanque de algas

## I. INTRODUCTION

To date, millions of people around the world do not have decent access to sanitation to meet their basic hygiene and health needs, leading to disease and thousands of deaths per year. Lack of sanitation not only affects humans, it also causes serious damage to the environment because bodies of water are contaminated with untreated wastewater.

Access to drinking water is a basic need of every human being that each country must fulfil for its inhabitants. Clean sources of water help guarantee proper sanitation so as to avoid diseases such as cholera, diarrhoea, dysentery, hepatitis A, typhoid and polio, diseases that result from the lack of water and that in many cases are fatal in infants. This is

clearly addressed in the United Nations' 2030 Agenda, within the SDG#6, "Ensure and sustainable management of water and sanitation for all". Lack of sanitation is related to target 6.2, which states "By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations" [1, p.35].

In areas that do not have a basic sanitation system many of their inhabitants defecate outdoors. This waste and other pollutants often end up in the water sources that the inhabitants use to supply themselves. If there is no water and sanitation facilities, or if they are inadequate or inadequately managed, the population will be exposed to preventable health risks [2, Water and health section].

The objective of this work is to address wastewater treatment for domestic or agriculture uses and sanitation installations in rural areas so that the inhabitants of these communities have a better quality of life, and thus continue to make progress related to the 2030 Agenda. To achieve this objective, this paper is organized as follows. First, this work addresses the problem, causes and consequences of lack of sanitation in rural and remote areas. Secondly, a system of algae ponds to treat wastewater will be presented. Finally, an analysis is made of the benefits and disadvantages that may arise from the proposed solution. It is expected that this paper may promote the implementation of alternative and sustainable methods for wastewater treatment.

## II. LACK OF SANITATION: ANALYSIS OF THE CAUSES AND CONSEQUENCES

The lack of adequate sanitation, for whatever reason, is not only harmful to humans, causing health problems, but affects the entire ecosystem surrounding those affected areas, generating greater pollution in water bodies and soils due to the wastewater.

### A. What is the sanitation problem in numbers?

The problems arising from the lack of sanitation are mainly health issues; deaths, diseases and lack of hygiene are the most serious problems faced by areas without basic sanitation facilities, areas that are mostly poor or far from large urban areas such as rural areas and even landlocked areas/countries. Some of these problems result in the following data:

- 1) According to a 2022 report from World Health Organization (WHO), just over half of the world's population (57%) used a safely managed sanitation facility as shown in the image below [6, Fig. 1]. More than 1.7 billion

> THIS IS AN ENGLISH AS A FOREIGN LANGUAGE ENGINEERING STUDENT PAPER. READERS MAY MAKE USE OF THIS MATERIAL AT THEIR OWN DISCRETION<

people still do not have access to basic sanitation, such as private toilets or latrines [3, Key facts].

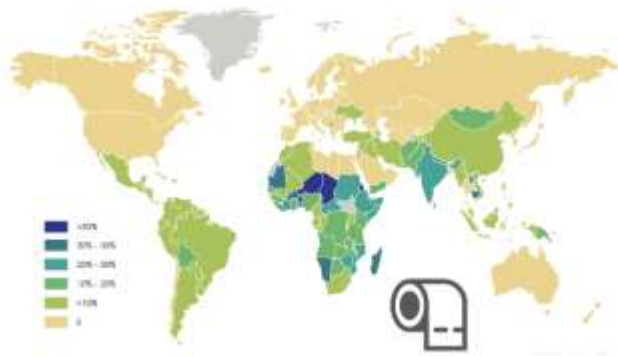


Fig. 1 percentage of people who defecate outdoors: >50%; 30%-50%; 20%-30%; 10%-20%; <10%; 0% [6]

- 2) In Argentina, according to census data from the Instituto Nacional de Estadística y Censo (INDEC) more than six million people do not have adequate sanitary facilities, do not have a bathroom, use a shared bathroom or one located outside the home.  
In addition, according to the latest INDEC household survey, more than 14 million people do not have access to public services such as running water and sewerage [4, Paragraph 2].
- 3) According to The World Bank, this crisis is most acute in rural areas. In these regions 91 percent of the people defecate outdoors and 72 percent of those live without basic sanitation [5, p.1]
- 4) According to the United Nations (UN) 2020 report, each year, 829,000 people die from diseases directly attributable to unsafe water, inadequate sanitation, and poor hygiene practices [6, p.1]

### B. What are the causes of sanitation issues?

The sanitation issues are caused by different factors. Some of these factors are remoteness, landlocked contexts, low development, poor governance and economy.

- 1) Remoteness: In Argentina, the percentage of coverage of access to safe water and sanitation in dispersed rural populations is well below the national average. More than 15% of people living in these areas must carry water from outside the home, a problem that particularly affects women and children [7, p.1].
- 2) Landlocked contexts: Many countries are in landlocked situations (i.e. do not have direct access to the sea). For some of them, this not is a great problem due to the fact that they are developed countries, such as Switzerland, while other countries (principally from Africa or South Asia) being a landlocked country is a serious problem because they not have enough resources

to counter their situation. For example, a landlocked country in the Himalayas, Nepal, has access to clean water from mountain rivers, but over 20 percent of the population lives below the poverty line. According to studies in Nepal, 75 per cent of drinking water samples from schools in Nepal were contaminated with human waste. Although open defecation is more common in rural communities, it still occurs in areas with access to sanitation, in order to decrease and try to eradicate this, lessons must be taught to prevent the dangers involved. In addition, open defecation pollution is further complicated by pollution caused by natural disasters such as floods. [8, p.1]

- 3) Poor Governance: Mismanagement of resources, corruption, human incapacity and lack of investment funds interfere in the correct leadership and manner of properly managing resources like water [9, introduction].
- 4) Economy: Beyond the social challenge, achieving universal access to basic sanitation represents a financial challenge. According to [10, conclusion] “The required investment is significant, although when put into perspective it represents “only” around 0.10% of the total GDP of low- and middle-income countries”. In this sense, “the real financial challenge of universal access to basic sanitation lies more in the lack of financial sustainability at the sectoral level than in the total investment required to reach the target”  
Around the world, localities that do not have a recent upgrade in their sanitation systems still run on lead pipes. In Argentina, we can find these sanitary facilities installed in the first half of the twentieth century. Lack of maintenance and replacement of these old pipes lead to frequent water cuts due to breakages that are becoming more frequent as illustrated in [11, fig 1].



Fig. 2 Rupture of a mother pipe in the city of Concordia, Entre Rios, Argentina in 2016 [11]

> THIS IS AN ENGLISH AS A FOREIGN LANGUAGE ENGINEERING STUDENT PAPER. READERS MAY MAKE USE OF THIS MATERIAL AT THEIR OWN DISCRETION<

### C. What are the consequences of sanitation issues?

The consequences of this problem are very varied, from pollution in the environment to deadly illnesses. The most important consequences are listed below.

- 1) **Illness:** According to a 2022 report by WHO, poor sanitation is linked to transmission of diarrhoeal diseases such as cholera and dysentery, as well as typhoid, intestinal worm infections and polio.[3, key facts].
- 2) **Low quality of life:** Poor sanitation reduces human well-being, social and economic development due to impacts such as anxiety, risk of sexual assault, and lost opportunity.
- 3) **Pollution:** According to a WHO report about sanitation, “inequalities in access are compounded when sewage removed from wealthier households is discharged into storm drains, waterways or landfills, polluting poor residential areas. Globally, approximately half of all wastewaters is discharged partially treated or untreated directly into rivers, lakes or the ocean” [3, Challenges].
- 4) **Safety risks:** Not having access to a safe and nearby location with, sanitation facilities cause risk like coming across snakes and other wildlife, as well as experiencing harassment and assault. Thus the risk of accidents and harm increases [12, p.1].

### III. ADDRESSING THE PROBLEM: ALGAE PONDS FOR WASTEWATER TREATMENT IN REMOTE AND RURAL AREAS

To achieve an adequate solution to the lack of sanitation in rural areas, it is necessary that it can cover the main problems that turn out to be causes or consequences mentioned before. One possible solution is related to algae ponds (APs). This section in this work discusses the properties of these ponds based on the study “Enhancement of algae ponds for rural domestic sewage treatment by prolonging daylight using artificial lamps” [13].

#### A. General features

Algae ponds are a method for water treatment which consists in stoking wastewater in big ponds with algae to be used as irrigation water later. Algae perform domestic wastewater treatment to remove contaminants in water. These organisms perform, through the process of photosynthesis, the work of removing nutrients and organic matter from the wastewater by reducing eutrophication in water bodies, which will treat water [13, p. 1].

#### B. Components

The material necessary to assemble an algae pond are polyvinylchloride (PVC) shells, inverted L-shaped flow baffles made of PVC material, PVC outlet pipes and full-spectrum light-emitting diode (LED) plant growth lamps to increase efficiency [13, P, 2].

#### C. Installation

The ponds are installed outdoors to take advantage of sunlight. During the setup period, activated sludge and river water collected from a body of water in the area are added to the ponds every four days for cultivating local dominant microorganisms and algae. Then the mixture remains until the end of the algae growth period [13, P, 2].

#### D. Use of water

This treated wastewater can be used in rural activities like irrigation or washing, but it is important to emphasize that this water is not suitable for human consumption. According to [12, p.7] “the quality of APs treated wastewater meets the requirements of the Water Quality Standard of Farmland Irrigation (GB5084 - 92), and the effluent can be used to grow cash crops to recycle nitrogen and phosphorus from domestic sewage”. Although this water is used for rural activities, wastewater is purified preventing people from getting sick because of this water.

### IV. FEASIBILITY ANALYSIS OF AN ALGAE POND: ADVANTAGES AND DISADVANTAGES

The proposal is based on an algae pond, which can be used for the treatment of wastewater and to reduce the cost of installation and maintenance of a typical wastewater treatment system, which requires resources that are often not available to rural and/or remote populations. This is not a perfect solution and this is why the advantages and disadvantages to the proposed solution are developed below.

#### A. Advantages:

- 1) **High temperatures:** This method is especially beneficial in hot areas, which often have a water shortage. The highest growth rate for algae is up to 28 degrees Celsius; when this temperature is exceeded, growth decreases. This is advantageous in areas where average temperatures are above average, but not excessively hot like in a desert area. For this reason, the algae ponds are efficient in a lot of areas [14, Discussion].
- 2) **Short pipe extension:** If decentralized, rural domestic sewage is treated with centralized wastewater management systems. The initial establishment of a large and complex pipe network is required, which can be costly in terms of infrastructure and operations, difficult to maintain, and difficult to achieve in most parts of the world. Algae ponds do not require large and complex piping resulting in a method less complicated to install than a conventional one. [13, P, 1].
- 3) **Zero water wastage:** According to UNICEF, in some rural areas water scarcity is considerable so it is important not to waste water in the process of sanitation. This method is very beneficial in relation to this aspect since it allows all the water to be recovered [15, P, 4].

B. Disadvantages:

- 1) Low temperatures: An algae pond usually has a difficult time thriving in cold weather. The nutrients it needs to survive usually from organic material are scarce. The water is cold and snow prevents the sunlight it needs from reaching the pond [16, p,1].
- 2) Low daylight density: Daylight is one of the biggest drawbacks of algae ponds, because to get the algae to continue their photosynthesis process, artificial lamps must be installed so that the pond works correctly all the time [13, P, 6]. This installation can be costly.
- 3) Contextual characteristics: This method is not viable in all rural or remote areas. Areas where water ponds are placed should be suitable for algal growth; very hot areas prevent algal growth due to high temperatures, while areas with low temperatures or damp areas prevent growth due to low sunlight.

V. CONCLUSION

Algae ponds are an excellent water treatment option in remote and rural areas. Due to the fact that rural or very remote areas often do not have adequate sanitation to maintain a good quality of life or cover basic hygiene and health needs, a solution based on algae pond is proposed.

Algae pond are will be used for wastewater treatment so that the premises can have better sanitation conditions and re-use this water in agricultural activities.

This solution is viable in certain rural areas that do not have extreme climatic conditions or unsuitable terrain (desert, mountainous or very cold areas)

REFERENCES

- [1] United Nations “The 2030 Agenda and the Sustainable Development Goals”, UN, New York, United States 2018. Accessed: 5 June 2023. [Online]. Available: <https://acrobat.adobe.com/id/urn:aaid:sc:US:dafe18f1-fb84-4c32-a974-8dcb32d9525e>
- [2] World Health Organization, “Water for human consumption” Report 2022, Ginebra, Suiza. <https://www.who.int/news-room/fact-sheets/detail/drinking-water> (accessed Jun. 5, 2023)
- [3] World Health Organization, “Sanitation Report 2023”, Ginebra, Suiza. 2023. Accessed: Jun. 15, 2023. [Online]. Available: <https://www.who.int/es/news-room/fact-sheets/detail/sanitation>
- [4] Multimedia Posibl, “Argentina: More than 6 million people do not have adequate sanitary facilities”. <https://www.posibl.com/es/news/pobreza/argentina-mas-de-6-millones-de-personas-no-cuentan-con-instalaciones-sanitarias-adecuadas-223e5f41> (accessed Jun. 15, 2023).
- [5] The World Bank, “Equitable and Sustainable Rural Sanitation at Scale”, Report October 7, 2019, Washington DC United State.

- <https://www.worldbank.org/en/news/feature/2019/10/07/rural-sanitation-matters> (accessed Jun. 15, 2023)
- [6] United Nation, “SDG#6”, Report 2020, New York, United States. <https://unstats.un.org/sdgs/report/2022/goal-06/> (accessed Jun. 15, 2023)
- [7] Ministerio de obras publicas, “Access to Water, Sanitation and Hygiene Programme in dispersed rural areas”, report 2022, Argentina. <https://www.argentina.gob.ar/obras-publicas/agua-potable-y-saneamiento/programa-de-acceso-al-agua-el-saneamiento-y-la-higiene-en> (accessed Jul. 12, 2023)
- [8] National Geographic, “Water Inequality”, Report 2023, United State. <https://education.nationalgeographic.org/resource/water-inequality/> (accessed Jul. 13, 2023)
- [9] UNICEF “Accountability in wash explaining the concept”, UNICEF New York, United State 2015. Accessed: 13, Jul 2023. [Online]. Available: <https://www.unicef.org/media/91311/file/Accountability-in-WASH-Explaining-the-Concept.pdf>
- [10] E. Perard, “Economic and financial aspects of the sanitation challenge: A practitioner approach”, ScienceDirect.com, June 2018. <https://www.sciencedirect.com/science/article/abs/pii/S0957178718301073> (accessed Jul. 13, 2023)
- [11] Newspaper Elentrierios, “Master pipe repaired and water service could suffer”. <https://www.elentrierios.com/actualidad/reparan-caao-maestro-y-podraa-resentirse-el-servicio-de-agua.htm> (accessed Sep. 11, 2023)
- [12] SIWI, “Water governance”. <https://siwi.org/why-water/water-governance/> (accessed Oct. 5, 2023)
- [13] Y. Mao, H. Tan, K. Wang, Y. Zhang, Z. Jin, M. Zhao, Y. Li, X. Zheng, “Enhancement of algae ponds for rural domestic sewage treatment by prolonging daylight using artificial lamps”, Elsevier 2021. Accessed: 25, Sep 2023. [Online]. Available: <https://acrobata.adobe.com/id/urn:aaid:sc:US:54a274a1-7144-4f68-bd03-f72dbcaa6a83>
- [14] Y.N. Kumar, S. Poong, C. Gachon, J. Brodie, A. Sade, P. Lim, “Impact of elevated temperature on the physiological and biochemical responses of *Kappaphycus alvarezii* (Rhodophyta)”, 2020. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7489555/#:~:text=In%20general%2C%20the%20growth%20and,above%20the%20optimum%20%5B33%5D> (accessed Sep. 25, 2023)
- [15] UNICEF, “Triple Threat”, UNICEF, New York, United State 2023. Accessed: 3 Nov 202. [Online]. Available: <https://www.unicef.org/media/137206/file/triple-threat-wash-EN.pdf>
- [16] Splash Supply Company, “How to Control Winter Pond Algae” <https://splashtsupplyco.com/how-to-control-winter-pond-algae/#:~:text=Pond%20algae%20usually%20has%20a,needs%20from%20reaching%20the%20pond.> (accessed Oct. 5, 2023)

Ramiro Acosta is an Civil Engineering student at UTN FRP: [ramiroacosta@alu.frp.utn.edu.ar](mailto:ramiroacosta@alu.frp.utn.edu.ar) . Bruno Ibarra is a Civil Engineering student at UTN FRP: [brunoibarra@alu.frp.utn.edu.ar](mailto:brunoibarra@alu.frp.utn.edu.ar).

The present manuscript is part of the research activities in the Inglés II lesson at Universidad Tecnológica Nacional, Facultad Regional Paraná. Students are asked to research into a topic so as to shed light on a topic of their interest within the National Academy of Engineering’s Grand Challenges or the United Nations’ Sustainable Development Goals frameworks. If sources have not been well paraphrased or credited, it might be due to students’ developing intercultural communicative competence rather than a conscious intention to plagiarize a text. Should the reader have any questions regarding thiswork, please contact Graciela Yugdar Tófolo, Senior Lecturer, at [gyugdar@frp.utn.edu.ar](mailto:gyugdar@frp.utn.edu.ar)