

Construction and design of a Solar Concentrator, with low cost materials for water disinfection and its application in marginalized communities

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Resumen

Objetivos: Desarrollar un colector solar con materiales de bajo costo disponibles en la comunidad; Que pueden ser contruidos por personas de cualquier edad, sexo o educación y ayudar a la eliminación de agentes biológicos en agua para consumo humano, cumpliendo con las disposiciones de la Reglamentación Oficial Mexicana vigente. **Contribución:** Mejorar la calidad de vida de las personas que viven en comunidades marginadas, con la elaboración de un prototipo de bajo costo. La calidad de vida si los países ricos y pobres del planeta crecen debido a diferentes factores, entre ellos hay el aumento de la tasa de crecimiento en las naciones más humildes. Se estima que tres cuartas partes de la población mundial viven en naciones humildes, mientras que el resto se encuentra en las regiones conocidas como países del primer mundo. Según la Organización Mundial de la Salud (OMS), se registra que hay 502.000 muertes por diarrea al año, causadas por enfermedades como la diarrea y el cólera. Los coliformes fecales y la bacteria E-coli en particular, han sido seleccionados como indicadores en el grupo de tifoidea-paratifoidea y su alta concentración en diferentes tipos de muestras. En algunas comunidades del país, algunas organizaciones civiles y el gobierno habían hecho esfuerzos para dotar a las comunidades de tecnologías apropiadas para la desinfección del agua. Sin embargo, muchas de estas tecnologías son caras e inaccesibles para muchas personas, por eso es importante contar con un sistema simple, funcional y eficiente.

Agua potable, coliformes, enfermedades, desinfección

Abstract

Objectives: Develop a solar collector with low cost materials available in the community; that can be built by people of any age, sex or education and help the elimination of biological agents in water for human consume, obeying with the provisions of the Official Mexican Regulations in force. **Contribution:** Improve the quality of life of the people that live in high marginalized communities, with the elaboration of a low cost prototype. The quality of life if rich and poor countries in the planet grow because of different factors, among them there's the increase in growth rate in the humblest nations. It is estimated that three quarters of the world population live in humble nations, while the rest is in the regions known as first world countries. According to the World health Organization (WHO), it is registered that there are 502,000 deaths because of diarrhea per year, caused by diseases such as diarrhea and cholera. The fecal coliforms and the E-coli bacterium in particular, have been selected as indicators in the group of typhoid-paratyphoid and to their high concentration in different types of samples. In some communities of the country efforts had been done by some civil organizations and the government for endowing the communities with appropriated technologies for the disinfection of the water. Nevertheless, a lot of these technologies are expensive and inaccessible for many people, that's why it is important to count with a simple, functional and efficient system.

Potable water, coliforms, diseases, disinfection

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Introduction

In the high marginalized communities of the country, one of the most frequent problematic situations is the lack of services. The deficiency of potable water is one of the problems that are presented most frequently and it can cause diarrheic illnesses which can cause even the death.

On the other hand the lack of drain and sewer services, generate fecalism in the open air; this situation joined with the lack of piped water and potabilisation systems cause severe gastrointestinal disease problems in the communities. The contamination of water bodies (such as fountains and springs used by human consume) caused by the movement of fecal matter is also very common.

The measurement of the quality of the water used for human consume establish a set of criteria that are in the "Norma Oficial Mexicana Nom-127-SSA1-1994" Which concludes that the water used for human consume should be submitted to a potabilisations process. Among the water criteria it is used as indicator organism of biological quality, the parameters of total coliforms and fecal coliforms, which are directly related to the contamination sources previously mentioned. The LMP for these parameters is 2MPN/100 ml and no detectable/100 ml, respectively.

The difficult access to the communities and the high price per unit of purified water makes hard and almost impossible to consume good quality water. The consume of water from springs, streams, rivers and rain water harvest are the alternatives to satisfy the basic needs related to water.

The use of methods such as disinfection by systems like chlorination, boiling water and the use of filters acquired through social programs, bring with them different problems. The bad taste generated by disinfection because of the excessive use of chlorine, causes rejection from people; adding to this, there are studies that reveal that the improper use of chlorine can generate problems of cancer; Because, in the presence of organic matter it forms as byproducts chloroform and carbon tetrachloride, substances considered as carcinogenic. Disinfection by boiling water causes in communities, problems related to inappropriate use of forest resources because the firewood is used as a general gas, also because of the emission of polluting gases. When the water is boiled, it acquires an unpleasant taste; for the water to have the optimum organoleptic properties is necessary to oxygenate it, the most common way is to pass it from a container to another one, but there is also the risk of crossed contamination.

The filters provided through social assistance programs does not represent, in the first instance, any type of problem, on the contrary, they represent an excellent alternative due to its high efficiency in processes of removal of contaminants of biological, physical and chemical nature; however, the constant government changes, cause the lack of tracing on the social problems, which leads to the end of useful life of the cartridges which lose their effectivity, to acquire them by the user in the community is hard because of the cartridge high cost.

Solar disinfection is not something new or revolutionary. There are different models that take advantage of sunlight as a source of disinfection either by heating or inactivation of bacteria and microorganisms resulting from the effects of UV radiation from sunlight, these have advantages as the use of clean energy, practically inexhaustible, which does not generate gas emissions, also it doesn't change the organoleptic properties of water, either its physicochemical properties so it is not necessary to transfer between different containers. The use of suitable containers does not involve the generation or release of materials harmful to health.

Explanation of the article sections:

Objetivo:

1. Develop a solar collector with low cost materials available in the community; that can be built by people of any age, sex or education and help the elimination of biological agents in water for human consume, obeying with the provisions of the Official Mexican Regulations in force.

Methodology:

2.1 Problem approach

2.2 Design of prototypes

2.3 Testing

2.5 Election of the Prototype

2.5 Results

2.6 Results analysis

2.7 Conclusion

Conclusion

The development of a solar disinfection low cost system aims to solve the problems related with the current disinfection systems used in communities, because they are built from elements such as wood, PTR, platen, and also during its use, it involves the disinfection of water in plastic bottles. The main problem is, on the one hand, working with these materials is difficult because of the context of most rural populations in Mexico and on the other, is the health factor, since the use of plastic bottles is not recommended under the conditions from the use of the device, that is to say that it is not recommended to place plastic bottles under the ray of sunlight or use it several times.

The construction of this prototype aims to solve these disadvantages, without compromising the quality of the water that must be used by people of the communities for its consumption.

The Technological University of Queretaro has made several projects for the improving of the quality people life, including:

- Implementation of green technologies in the community of El Pinalillo.
- Design and development of a prototype of a basic unit of a rural housing.
- Model of decision maker for the installation of hidrotechnologies and management of basins in the disperse localities of high marginalization.

The participation of staff and students of the institution has let identified the various problems in the country communities.

Justification

In Mexico diarrheal diseases are among the leading causes of infant mortality, is one of the major public health problems.

Usually due to bacterial, viral and parasitic infections that are transmitted by food consumption especially fruits, vegetables and water contaminated with both, human and animal fecal matter, or with fluids such as urine. According to the WHO (1) in the world there are 2.2 million deaths from gastrointestinal illness-related deaths in a year.

From 1990 to 1997 in Mexico 103 812 (2) persons died from intestinal infectious diseases according to INEGI data, in the year 2000 there are reported 5207 deaths (3) The most common bacteria are *Salmonella tophi*, *Listeria monocytogenes*, *Vibrio cholera*, *Escherichia coli* are reported and *Leptospira interrogans*, which cause typhoid fever, gastroenteritis, cholera, diarrhea.

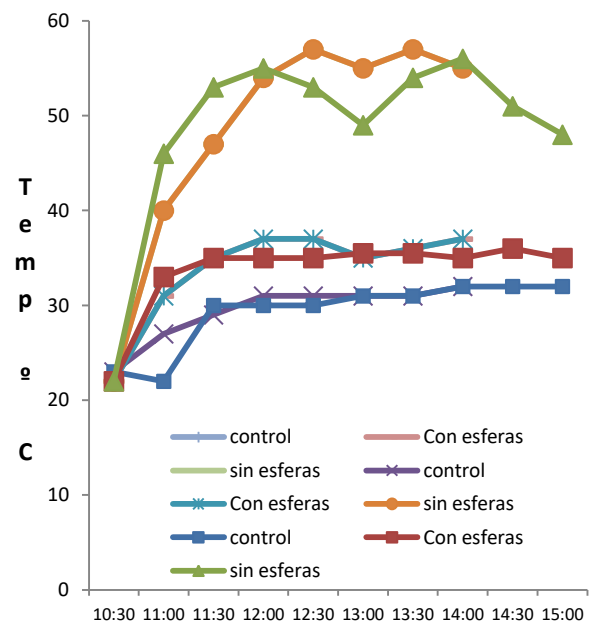
These parasites are due inadequate practices for the disposition of excreta and environmental sanitation. Both, water and food are very easy to pollute.

Development

Two prototypes were elaborated to evaluate the efficiency of the temperatures that could reach the bottles when they were in sun exposure. The first prototype was made by lining a plastic ball with newspaper and glue with several layers to make the mold of the sphere, after obtaining the mold; we proceeded to line it inside with reflective paper food products like cookies, candy, sabritas, etc. In the second prototype we made the mold of the sphere in the same way as the first one, with newspaper and reflective material, But we placed inside this sphere ball form a smaller size that were firstly lined with reflective material such as the first ones.

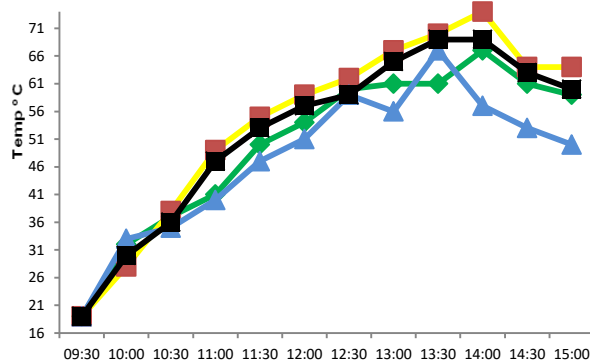
Data is analyzed to select the collector with higher temperatures. In this case, the collector that has no spheres.

From these test results, it is observed that there is no a significant temperature difference.



Graphic 1 Selection of the collector.

Once having selected the type of collector there are measured different types of container, for it we select that glass bottles that are easily to get. Bottles of different colors are selected: green, amber, clear, blue and then it is painted a bottle with black matte paint. This test assesses if the color of the bottle has an effect on the temperature of the water that is pretended to be irradiated. The tests are performed during the month of November 2013.

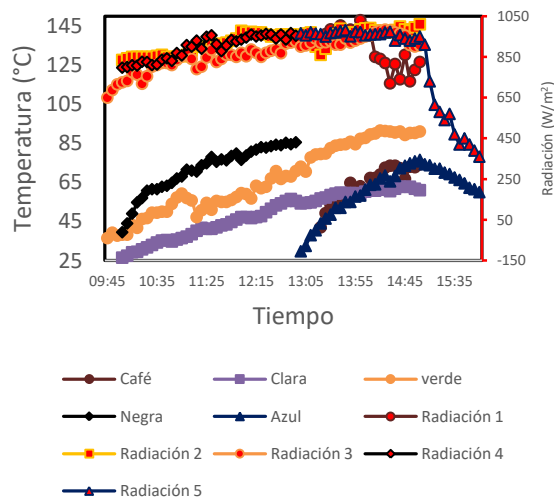


Graphic 2 Selection of container

From these test results, it is observed that there is no a significant temperature difference.

Because the results do not show that the color of the bottle influences the results in a clear way, it is necessary the realization of tomograms searching a more concrete result.

Promedio de Temperaturas vs Radiación



Graphic 3 Termography

It can be concluded that it is checked the measured firstly and it does not exist a behavior that helps us to define the best type of container for the final tests, that's why the criteria for defining the ideal container will be done by the facility for obtaining it in the community and it is chosen the amber container.

The next stage of the research: the different containers are injected with rising amounts of inoculum. This inoculum is taken as the following way: the containers are filled with tap water and mixed with sanitary wastewater without any type of treatment. Different amounts of inoculum are analyzed seeking to reach high concentrations in the number of coliforms and to try the different containers.

Results

Test 1. January 14 containers with 700 ml of tap water + 5 ml of AR.

Test 2. Feb. 4, containers with 700 ml of tap water + 10 ml of AR.

Test 3. February 17 containers with 700 ml of tap water + 15 ml of AR.

In all containers the same results were obtained. Based on the PROY-NMX-AA-042-SCFI-2011 standard the result of all tests are <2 MPN / 100 ml.

03-Mar-14	
Nombre	
Variación en tiempo de exposición	
Condiciones	
5 Contenedores AMBAR y testigo con 700 mL de agua de la llave + 20 mL de AR	
Se irradian de las 10 a las 18 hr , Parcialmente nublado a partir de las 14:00 hr	

Table 1 Test Conditions variation exposure periods

	A	B	C	D	E
10:00	x				
11:00	x				
12:00	x	x			
13:00	x	x			
14:00	x	x	x		
15:00	x	x	x		
16:00	x	x	x	x	
17:00	x	x	x	x	x
18:00	Cancelado por lluvia				

Table 2 Test conditions of varying exposure periods

Contenedor	NMP 100 mL de mtra	
	CT	CF
A	0	0
B	0	0
C	0	0
D	2400	210
E	2400	1100
Testigo	2400	2400

Table 3 The above test results.

Different variations in the experiments were made increasing the concentration of residual water to obtain results without bacterial growth, until arriving on the next test.

06-Junio 14
Nombre
Concentrador esférico
Condiciones
2 Contenedores AMBAR , con 1000 mL de AR (SIN DILUCIÓN) Se irradian de las 9:00 a las 18 hr ,

Table 4 Test conditions without dilution.

Giving as a negative result: <2 MPN / 100 ml. A safety test is performed with the following conditions.

- This test was performed in the amber bottles

- It was worked with concentrated wastewater without dilution
- The bottles are irradiated on 21 July from 8 hours to 18 hours.
- It is sat overnight and it begins to sow on July 22
- The samples are stored at room temperature in dark conditions and replant every 24h
- And the following results are obtained:

:

	Horas después de la insolación	Resultados NMP / 100 mL
Martes 22 julio	24	< 2
Miércoles 23 de julio	48	< 2
Jueves 24 de julio	72	< 2
Viernes 25 de julio	96	< 2
Sábado 26 de julio	120	< 2

Table 5

Conclusions

Solar thermal energy is an inexhaustible source of energy and it can be used to improve water quality for human consumption at a very low cost in marginalized communities.

The color of each bottle was not significant for the elimination of coliforms.

The safety test shows that coliform bacteria can be inactivated for more than seven days, that's why we believe that they were completely eliminated.

The prototype was tested under different exposure conditions to test its robustness, evaluating exposure periods and reached temperatures..

There were eliminated total and fecal coliforms in wastewater samples with concentrations greater than 2400 MPN / 100ml, with temperatures above 55 ° C and a longer time exposure to 4 hours.

We have to remark that the tests were made between October and April, where the amount of solar radiation in the state of Queretaro is not the maximum, so it is possible to use this technology throughout the whole year and in areas with lower index radiation.

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