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Assessment of the quality of the drinking water source (well 1)

Evaluación de la calidad de la fuente de captación (pozo 1) de agua potable

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Abstract

In Ecuador, there are many places that do not have drinking water, which is why citizens have to find ways to obtain this element that is so essential for living beings. To do so, they have to look for sources of water, whether underground or surface sources. However, in order to use or consume it, they first have to undergo a series of tests to determine whether the water from the source is fit for human consumption. For our study, we will focus on the rural area of the Marcelino Maridueña Canton, since part of this population obtains its water supply from underground wells. We will therefore conduct tests to analyze whether the water consumed by this population contains

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elements that could be harmful to their health, since the presence of certain elements such as heavy metals or agrochemicals in the water can be very harmful to the health of those who consume it consume it. If the water contains these harmful elements, we will identify them in order to propose a solution and thus comply with the parameters established in current regulations, achieving a better quality of life for the inhabitants of the sector and serving as a warning to the sectional authorities to implement the necessary controls so that the water source is not contaminated.
Keywords Standards, water, human consumption

Resumen
En Ecuador existen muchos lugares que no cuentan con agua potable por este motivo los ciudadanos tienen que buscar la manera de obtener este elemento que es tan esencial para los seres vivos, para ello tienen que buscar fuentes de captación ya sean estas fuentes subterráneas o superficiales, sin embargo para poder utilizarla o consumirla primero tienen que pasar por una serie de análisis que permita conocer si el agua de la fuente de captación es apta para el consumo humano, para nuestro estudio nos centraremos en la zona rural del Cantón Marcelino Maridueña ya que una parte de esta población se abastece de agua mediante pozos subterráneos por ende analizaremos mediante ensayos si el agua que está consumiendo esta población no contiene elementos que produzcan daños a su salud ya que la presencia de ciertos elementos como metales pesados o agroquímicos en el agua puede llegar a ser muy perjudicial para la salud de quien la llegase a consumirla y si el agua presenta estos elementos dañinos identificarlos para poder proponer una solución y de esta manera cumplir con los parámetros establecidos en las normativas vigentes, logrando

una mejorar calidad de vida para los habitantes del sector y sirviendo de alerta para las autoridades seccionales e implementar los controles necesarios para que no se contamine la fuente de captación.

Palabras clave Normas, agua, consumo humano

Introduction

In the Marcelino Maridueña district, the population obtains water from underground sources, as for rural areas such as this one, it may seem more convenient to use this type of source because it has less turbidity and fewer solids than surface sources, which is why they built groundwater wells.

However, citizens are often unaware of the risks involved in consuming water from this type of source without carrying out the necessary analyses, as groundwater may contain minerals or heavy metals and/or agrochemicals, which, when consumed by the population, can result in various types of diseases, including cancer, which is one of the most serious. For this reason, certain laboratory tests will be carried out to assess the quality of the water that these inhabitants are consuming and thus prevent or mitigate risks to their health. Once the results of these analyses have been obtained and compared with the parameters set in the current regulations, if substances are found whose concentration levels represent a latent danger, the optimal treatment to remedy the problem will be proposed, thus improving the quality of the water from the collection source and providing the right to a water resource with the necessary conditions to ensure the well-being of all inhabitants.

This will be further expanded upon in the chapters that will be detailed in the thesis and its execution.

Since ancient times, humanity has sought to settle near freshwater sources, generally rivers, such as the Mesopotamian civilization that settled near the Tigris and Euphrates rivers (2350 BC) or the Egyptian civilization that settled near the Nile River (1580 BC). Many other civilizations that developed in ancient times have this in common. In Ecuador, there are also cases of this. Guayaquil settled near the Guayas River, to highlight the most important ones. However, since not all cities or cantons can be located near a river, inhabitants must find ways to obtain this important element, water, and to reduce the deficit, they choose to build water wells to obtain water from this underground source. Generally, an extensive analysis of all the agents or substances that could be present in raw water is not carried out. However, these studies are necessary to safeguard the health of the inhabitants who consume it.

While it is true that institutions such as COOTAD (Organic Code of Territorial Organization, Autonomy, and Decentralization) or the GADS (Decentralized Autonomous Government) request that those in charge of the water supply project carry out laboratory tests, they do not generally specify the total parameters that must be met in order to consider that source of water suitable for use. The current standard "Norma NTE INEN 1108:2014" shows us the maximum permitted limits for a considerable number of parameters, but it does not establish or require that the respective laboratory analyses be carried out for all of them, leaving this evaluation to the discretion of the project owner. This means that certain parameters that may be extremely important in terms of their influence on the water body under study are omitted, either due to ignorance or to reduce costs.

Using data and records from the latest census, it can be seen that the coverage levels of drinking water services at the national level increased by 6.0% in 2010 to 80.4% and 8.6% in 2014 to 86.4%, and sanitation services from 64.5% to 73.1%, respectively.

According to this same data and treatment, the access gap between cantonal capitals and the rest of the territory was drastically reduced, from 24.3% to 15.9% for drinking water and from 24.3% to 15.9% for sanitation.

According to this same data and treatment, the access gap between cantonal capitals and the rest of the territory was drastically reduced, from 24.3% to 15.9% for drinking water and from 17.9% to 3.3% for sanitation.

However, when we analyze the ECV coverage data, we note that the gap between dispersed rural areas (less than 2,000 inhabitants) and the rest of the country's localities is still very significant: 19% and 13% for water and sanitation, respectively.

This suggests that municipal GADs' investment efforts in water and sanitation are concentrated in parish capitals and concentrated rural areas (Senagua, 2014).

In the canton of Coronel Marcelino Maridueña, we can see that the supply available to residents does not guarantee the quality of the water they are consuming, since institutions such as COOTAD (Organic Code of Territorial Planning, Autonomy, and Decentralization) or GADS (Decentralized Autonomous Government) do not specify the total number of tests that should be carried out in order to guarantee the quality of the water consumed by the inhabitants of the canton, as required by the current standard "Norma INEN 1108:2014."

Once the parameters and the location where the assessment will be carried out and the source of collection (well 1 and well 2) are clear, the respective analysis will be carried out to determine whether it contains lead (heavy metal) and organochlorine pesticides (agrochemicals), generating a report that will be presented to the authorities in charge. Depending on the results, actions will be taken to improve water quality, thus positively changing the quality of life of the inhabitants of the area, mitigating the future risk of disease caused by the consumption of contaminated water.

The Marcelino Maridueña Canton belongs to the province of Guayas, in the Republic of Ecuador. Its capital is Marcelino Maridueña, located 65 km from the city of Guayaquil. It is located in the east of the province, at an altitude of 80 meters above sea level, with an average temperature of 24 °C and an average annual rainfall of 1700 mm (Municipal GAD of the Canton of Coronel Marcelino Maridueña, 2014).

The Marcelino Maridueña canton is where samples are taken for testing to assess whether the water analyzed from well 1 and well 2 is within the maximum permissible limits set by INEN 1108:2014.

- Well 1 is located at the following coordinates: E: 673381; N: 9755480.
- Well 2 is located at the following coordinates: E: 673333; N: 9754440.

According to data obtained in the 2001 census, the population of the Marcelino Maridueña Canton represents 0.3% of the total population of the Province of Guayas. It has grown in the last period between the 1990-2001 censuses at an average annual rate of 0.02%. Thirty-nine point two percent of its population resides in rural areas. It is characterized by a young population, as 41.0% of the population is under 20 years of age, as can be seen in the population pyramid by age and sex (Municipal GAD of the Coronel Marcelino Maridueña Canton, 2014).

According to data from the 2010 INEC census, the canton of Marcelino Maridueña has a total population of 12,033 inhabitants in urban and rural areas. In the urban area, the population is 7,163 inhabitants, of whom 3,674 are men and 3,489 are women; in the rural area, the population is 4,870 inhabitants, of whom 2,591 are men and 2,279 are women

(Municipal GAD of the Canton of Coronel Marcelino Maridueña, 2014).

According to INEC data (2010 Census), the most representative age group of the total population, and the one that defines certain characteristics of the demography of the Marcelino Maridueña canton, is between 30 and 64 years old (adults); then we have the group of children and adolescents.

Next are young people, who make up 20.58% of the total population. The group referred to as older adults (over 65 years of age) accounts for 12.61% (Municipal GAD of the Canton of Coronel Marcelino Maridueña, 2014).

When describing the composition of the population according to the number of men and women in each age group, we find that:

- Among those aged 0-11, which includes children, and those aged 12-17, which includes adolescents, 56.86% are men and 49.45% are women.
- Young people are between 18 and 29 years old, with 26.60% being women and 29.58% being men.
- Adults are between 30 and 64 years old, with 35.19% being women and 36.33% being men.
- Older adults, who are those over 65 years of age, 23.64% are women and 29.88% are men.

In the Marcelino Maridueña canton, 35% of the population is supplied by the public network. According to the data, 52% is urban area, while 9% is rural area.

The canton has a piped water system that supplies the entire urban population, but this is not the case in the surrounding areas, where water is supplied by extracting groundwater from wells, for example, to an elevated tank and then distributing it through pipes and hoses to homes. The system will not present any problems if the population does not increase and, therefore, neither does demand, but this situation is already developing.

The system has drawbacks due to the lack of maintenance that has been given to the towers and storage tanks, which is determined to be a problem for water distribution. There is also a need to increase the flow of the pipes.

In conclusion, we determined that the installation of water distribution networks has 90% coverage, with 10% still to be operated.

Therefore, we can say that the canton has a drinking water network that supplies homes through pipes with a length of 26,906 linear meters, leaving 2,932 linear meters to be served (Municipal GAD of the Canton of Coronel Marcelino Maridueña, 2014).

Since the wells do not require deep drilling and provide easy access to fresh water, this water is used in homes and is supplied by these wells, reaching homes through pipes.

According to data from the 2010 Census, 2,268 homes have water connections inside the home, 542 homes have pipes outside the home, and 269 homes receive water by other means (Municipal GAD of the Canton of Coronel Marcelino Maridueña, 2014).

Sewerage coverage in the canton is 55.2%, which is relatively higher than the national coverage percentage (53.6%) and slightly higher than the provincial coverage (46.7%). These values have remained stable between the 2001 and 2010 censuses, meaning that, although the population has increased considerably, adequate measures have been taken to ensure that residents have an acceptable quality of life. We must consider that the level is still not high, but it is not critical either (Municipal GAD of the Coronel Marcelino Maridueña Canton, 2014). Ninety-four percent of homes have electricity, which is almost on par with the national percentage and slightly above the provincial percentage. Depending on the geographical location, the gaps are smaller than in the previous indicators. However, differences can still be seen between urban areas, where the coverage percentage is 99.3%, and rural areas, where it barely reaches 87.9% (Municipal GAD of the Canton of Coronel Marcelino Maridueña, 2014).

Lead occurs naturally in the Earth's crust and is a toxic metal. It is a cation-charged element that has caused serious problems of environmental pollution and human health.

Lead is a heavy metal that has been used for many years due to its resistance to corrosion, ductility, malleability, and ease of forming alloys. Among the main sources of environmental pollution are mining, metallurgy, manufacturing and recycling activities, and, in some countries, the persistent use of leaded paints and gasoline. More than three-quarters of global lead consumption is for the manufacture of lead-acid batteries for motor vehicles. However, this metal is also used in many other products, such as pigments, paints, soldering material, stained glass, glass tableware, ammunition, ceramic glazes, jewelry, and toys, as well as in some cosmetics and traditional medicines. Drinking water piped through lead pipes or soldered with this metal may also contain lead. Currently, much of the lead traded on world markets is obtained through recycling (WHO, 2018).

Ingestion of this type of substance can occur through inhalation of dust containing lead, contaminated water, or contaminated food. Lead is generally distributed throughout different parts of the body, such as organs, tissues, bones, and teeth, where it accumulates over time. Lead poisoning can vary depending on the level of exposure and the age of the person (Reyes, Vergara, Torres, Díaz Lagos, & Gónzales, 2016).

Absorbing or ingesting lead is a serious public health risk, as its ingestion leads to problems such as delayed mental and intellectual development in children and causes hypertension and cardiovascular disease in adults. Poisoning can occur through accidental consumption, such as eating contaminated food. Oral absorption of lead occurs in 10% of adults and can increase to 50% in children. Absorbed lead can be distributed in the kidneys, liver, brain, and bones due to its similarity to calcium. The largest deposit of lead is in the bones for up to 20 years; it interferes with calcium function, inhibits hemoglobin synthesis, and causes neurological damage (Londoño Franco & Londoño Muñoz, 2016).

The effects can be severe on the central nervous system, consisting of paresthesia, muscle pain and weakness, hemolytic crisis, severe anemia, and hemoglobinuria. It also affects the kidneys, causing oliguria and albuminuria. Although acute poisoning can cause death, it is more common for the patient to recover and present with chronic poisoning with gastrointestinal, neuromuscular, nervous, hematological, renal, and reproductive damage. At the gastrointestinal level, there is anorexia, headache, constipation, intestinal spasm, and abdominal pain. Neuromuscular symptoms include muscle weakness and fatigue followed by paralysis of the forearm, wrist, and fingers, and sometimes the feet. These symptoms were characteristic of painters' disease, but today the replacement of lead pigments and improvements in industrial safety and hygiene conditions are leading to the disappearance of this type of poisoning (Londoño Franco & Londoño Muñoz, 2016).

The first symptoms of encephalopathy in children are lethargy, vomiting, irritability, loss of appetite, and dizziness, which progress to ataxia, reduced consciousness, and ultimately coma and death.

The mortality rate from lead encephalopathy is high, approximately 25%, and many of the patients who recover are left with sequelae, including mental retardation, seizures, and optic atrophy. Lead exposure has been associated with infertility and neonatal death in humans. In animals, it has been shown to have a toxic effect on gametes and to increase the concentration of lead in maternal blood, which reduces the duration of gestation and the birth weight of offspring. Lead can trigger teratogenic effects in the fetal nervous system and interfere with normal development. Lead and its compounds are classified in group 2B, probably carcinogenic to humans (IARC) (Londoño Franco & Londoño Muñoz, 2016).

The chemical composition of well water in this case can vary depending on a number of factors, including the region where it is located, its geological formation, and the environmental pollution to which the area may be subject. Some of the toxic substances that can contaminate water are attributed to the type of soil that may contain this contaminant and to agricultural or industrial areas in the vicinity of the source.

Lead can also contaminate well water in the following circumstances:

1. Lead can exist naturally in soil and rocks and can seep into groundwater.
2. From hazardous waste deposits, refineries, recycling centers, battery crushing, or industrial sources of lead.
3. However, lead usually enters the water through the system's pipes, brass faucets, or solder.

Lead can usually seep into drinking water when lead service pipes corrode, especially where the water has high acidity or low mineral content, which facilitates corrosion of the pipes and fixed elements of the system. The most common problem is caused by brass or chrome-plated brass faucets and fixed elements with lead solder, which can result in concerning amounts of lead in the water. Lead can infiltrate the water, especially hot water (EPA, 2017).

Producing clear water without fine solids is a prerequisite for providing the population with low-turbidity water, which is why the filtration process is essential.

Filters are generally thought of as a sieve or micro-screen that traps suspended material between the grains of the filter medium. However, the action of straining, screening, or sieving the water is the least important part of the filtration process, since most suspended particles can easily pass through the spaces between the grains of the filter medium (Romero Rojas, 1999).

Filtration is a combination of physical and chemical mechanisms. It can be said that absorption is essential for drinking water, since as the water passes through the filter bed, particles are retained upon contact (Romero Rojas, 1999).

Filter beds must have certain characteristics, such as:

- Grain size.
- Grain size distribution.
- Density, shape, and composition of the grain.
- With these three parameters, we can evaluate the efficiency of particle removal.
- Porosity of the filter bed; this determines the amount of solids that the filter can store.
- Filtration rate; this affects the quality of the effluent and determines the area required.

Characteristics of the influent or catchment source; this determines the removal capacity of the filter.

There are different types of filters, including:

Slow sand filters.

These have the following characteristics: a filtration rate of 2-5 (<12 m/d), a sand stratum, no wash water, a depth of 0.6-1.0 m, a gravel depth of 0.30 m, and drainage through perforated pipe.

Rapid sand filters.

These have the following characteristics: a filtration rate of 120 m/d, a sand stratum, backwash water present at 2–4% of the filtered water, a depth of 0.6–0.75 m, a gravel depth of 0.30–0.45 m, and drainage through perforated pipe false bottoms.

High-rate filters.

It has the following characteristics: a filtration rate of 180–480 m/d, a sand and anthracite stratum, wash water present is 6% of the filtered water, the depth of the anthracite is 0.4–0.6 m and of the sand 0.15–0.30 m, the depth of the gravel is 0.30-0.45 m, and drainage is provided by perforated pipe false bottoms.

Cellulose acetate (and its derivatives) is one of the most widely used materials, as are aromatic polyamides.

Methodology

We will use an analytical methodology, as tests will be carried out for the presence of agrochemicals and a heavy metal has been chosen to assess their presence in this case. We will determine whether lead (Pb) is present in the catchment source and analyze whether the quantities generated by the tests are within the ranges permitted by both the regulatory body and the current legal framework.

It is necessary to determine the nature of the sampling, i.e., where the samples will be taken. If the source of the catchment is an estuary, stream, river, reservoir, well, lagoon, or lake, the type of soil in the vicinity must be considered, as well as whether it may contain crops or any external contaminants that could affect the type of source to be evaluated.

We must know the types of samples that can be used:

If it is known that the source where the sample is to be collected has a constant composition in time or space, a simple survey can be considered, but if it is known that the source has variations of any kind, more samples must be taken at different times in the same place.

Composite samples are those collected at different times in the same place. For analysis purposes, composite samples can be taken over a period of 24 hours.

These samples are collected at different locations, but at the same time, this type of sampling is most commonly used in rivers, lakes, reservoirs, or places that undergo changes in composition due to the presence of currents. The use of special equipment is recommended.

In order to obtain optimal results and ensure that the sampling does not influence them, the following steps should be followed:

- Samples should be labeled with the name of the person or entity taking the sample, the sample number, the time, the date, and the location where it was taken.
- The sample should be properly sealed.
- It is recommended to record field data such as the location, the number of samples taken and their volume, a description of the location, and any other information that may be useful.

Containers can be made of glass or plastic, but because some substances, such as cations including cadmium, lead, iron, aluminum, copper, zinc, and manganese, can be absorbed by the walls of glass containers, they are not recommended as they alter the nature of the sample. Samples should be taken in plastic containers.

If the samples cannot be analyzed immediately, they must be stored at 5°C from the time they are collected until they are taken to the laboratory and the respective analyses are performed.

The containers used must be able to hold a minimum of 250 ml, but if the analytical technique requires it, a larger capacity container must be provided.

Results

The first samples taken from wells 1 and 2 were delivered to the Marcos Chemical Group laboratory, which is accredited by the SAE (Ecuadorian Accreditation Service). The entity provided the results on December 11, 2018.

The first samples were analyzed for organochlorine pesticides (agrochemicals) and lead (heavy metals).

The results showed that organochlorines are present, some in higher proportions than others, but due to the analysis method, it cannot be verified whether they are within the maximum permissible limit of INEN 1108:2014. A comparison table of the results with the different standards is provided below:

In the case of lead (heavy metal), it was chosen as an indicator of the presence of heavy metals in the catchment source, with the results showing that this element is present in well 1, but above the maximum permissible limit according to INEN 1108:2014. Well 2 also contains this element within the maximum permissible limit of INEN 1108:2014. A table comparing the results with the different standards for the two wells is provided below:

After analyzing the results of the first sampling and observing that the presence of organochlorines is within the permissible limits, but that of lead in well 1 is above the maximum permissible limit according to the standard, it was decided to take a new sample only for this element from the well in question and take it to three different laboratories to verify that the results of the first sample were not erroneous. The samples were delivered to the PSI (Productos y Servicios Industriales C. LTDA.), SGS del Ecuador S.A., and Bureau Veritas laboratories, noting that these laboratories are accredited by the SAE (Servicio Acreditación Ecuatoriano).

Once the results were obtained, we found that lead is present in the water source and exceeds the permissible limits. A comparison table of the results with the different standards and the different results from the laboratories that tested the samples is provided.

With the results, a suitable treatment method for water containing lead will be proposed. We propose that the treatment method be reverse osmosis, since according to the filtration spectrum, this is an appropriate method for this type of contaminant. The method in question will be detailed below. In order to carry out the reverse osmosis treatment, we first propose a pretreatment with filtration, followed by the reverse osmosis process and, finally, a disinfection process.

Filtration will remove turbidity and possible microorganisms, followed by reverse osmosis to reduce the lead content, which is the problem at hand. Finally, disinfection is proposed to reduce or eliminate microorganisms, mainly pathogens, present in the well water. The aim of this system is to make the collected water suitable for human consumption and compliant with current standards such as "INEN 1108:2014 ," and that the costs are not too high, as methods such as aeration, coagulation, flocculation, and sedimentation are not considered because the characteristics of the water do not warrant them, and the areas of operation of the proposed system would be much smaller than that of a complete system.

Conclusions

Although the results obtained show that the levels are below the established limits, the importance of monitoring and regulation studies to ensure the safety of citizens is highlighted (Reyes, Vergara, Torres, Díaz Lagos, & Gónzales, 2016).

This assessment seeks to raise awareness among local governments about the importance of conducting preliminary evaluations to ensure optimal quality of water collection sources.

Laboratory tests determined that the lead content exceeded the maximum limits allowed by regulatory bodies; therefore, a three-stage system has been proposed to reduce this concentration and bring it within the permissible range. These stages consist of pre-treatment (filtration) + treatment (reverse osmosis) + disinfection (chlorination).

·A visual inspection revealed a lack of maintenance of the pipes that transport the vital liquid, which is likely to be one of the sources of contamination.

The wells (well #1 and well #2) lack a treatment system (filters or disinfection) prior to distribution to the community, which is contributing to the deterioration of the health of its inhabitants.

Reference

Aguero, R. (1997). Agua potable para poblaciones rurales. Lima: Asociación Servicios Educativos Rurales (SER).

Diseños y Soluciones Sostenibles DSS. S.A. (2017). DSS. Obtenido de http://dss.com.ec/wp-content/uploads/2012/07/osmosis_inversa.pdf

EPA, A. d. (19 de Enero de 2017). Agencia de Protección Ambiental de Estados Unidos. Obtenido de Información Básica sobre el Plomo en el Agua Potable: https://espanol.epa.gov/espanol/informacion-basica-sobre-el-plomo-en-el- agua-potable

Fariñas Iglesias, M. (1999). Fundamentos, Tecnologías y aplicaciones. España: McGrawHill.

GAD Municipal del Cantón Coronel Marcelino Maridueña. (2014). Actualización del plan de desarrollo y ordenamiento territorial. Gobierno Autónomo Descentralizado Municipal del Catón Coronel Marcelino Maridueña. Coronel Marcelino Maridueña: Sistema Nacional de Información.

Londoño Franco, L. F., & Londoño Muñoz, P. T. (2016). Los Riesgos de los Metales Pesados en la Salud Humana y Animal. Biotecnología en el Sector Agropecuario y Agroindustrial, 145-153.

Nemerow, N., & Dasgupta , A. (1998). Tratamiento de Vertidos Industriales Peligrosos. Madrid: Dias de santos.

O.M.S., O. M. (23 de Agosto de 2018). Organización Mundial de la Salud. Obtenido de Intoxicación por plomo y salud: https://www.who.int/es/news-room/fact-sheets/detail/lead-poisoning-and-health

Ortega, J. M. (21 de Agosto de 2001). La ósmosis inversa como proceso de potabilización en España. Honduras: AIDIS.

Prieto Méndez, J., Gonzáles Ramírez, C., Román Gutiérrez, A., & Prieto Garcia, F. (2009). Contaminación y fitotoxicidad en plantas por metales pesados provenientes de suelos y agua. Tropical and Subtropical Agroecosystems,

Reyes, Y., Vergara, I., Torres, O., Díaz Lagos , M., & Gónzales, E. (2016).

Contaminación por Metales pesados: Implicaciones en salud, ambiente y seguridad alimentaria. Revista Ingeniería y Desarrollo.

Rice, E., Baird, R., & Eaton, A. (2017). Standard Methods for the Examination of Water and Wastewater. Estados Unidos: American Water Works Association.

Romero Rojas, J. A. (1999). Potabilización del Agua. Colombia : Alfaomega . SAE, S. D. (2018). Plan Estrátegico Institucional. 44.

Senagua. (2014). Fase I: Diagnóstico, prioridades, estrategias y propuestas programáticas. Estrategia Nacional de Agua Potable y saneamiento, 80.

Thake, P. (2010). Dispositivos de elevación del agua. Mexico: Alfaomega Grupo Editorial, S.A. de C.V.