Polluted domestic water in Costa Rica
- Analysis from a technical and an economical perspective

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ABSTRACT

The aim with this project was to investigate pollution of a water resource from fertilizer used in coffee plantations and to investigate the inhabitants’ willingness to pay to maintain a good quality of the drinking water. Concentrations of nitrite and nitrate in water taken from a coffee plantation were compared with water from an area not as fertilizer intense. During seven weeks groundwater was taken weekly from the coffee farm La Pequeña, San Isidro. Surface water was taken weekly from the national park Los Chorros, Tacares de Grecia. Both areas are situated in the Central Valley, Costa Rica and they provide drinking water for the cities Atenas, Orotina and Alajuela. The water samples taken from La Pequeña had concentrations of about 14mg/l NO₃⁻ and the samples from Los Chorros had concentrations of about 3.5 mg/l NO₃⁻. Concentrations of nitrate in water from the coffee plantations were therefore high just as suspected. Concentration of NO₂⁻ varied as NO₂⁻ is an unstable chemical form of nitrogen, N. The mean WTP for the people interviewed was €1,400 per month. The willingness to pay, WTP, was examined through interviews with people living in these areas. The mean WTP increased with a higher total household income and level of education. Many of the respondents were content with the water quality but still willing to pay more for their drinking water. Even if opinions of the current water cost differed the mean WTP were the same. The group with confidence for the distributor had a higher mean WTP. A continuation of the project could be to take water samples at least during a year to study the seasonal variations of concentrations of nitrate and nitrite. A cost benefit analysis could also be of interest to make.

Keywords: [Costa Rica], [drinking water], [fertilizer], [coffee], [nitrate], [nitrite], [willingness to pay], [environmental valuation], [contingent valuation method]
SAMMANFATTNING


Nyckelord: [Costa Rica], [dricksvatten], [gödningsmedel], [kaffe], [nitrat], [nitrit], [betalningsvilja], [miljövärdering], [contingent valuation method]
# ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
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| ARESEP       | Autoridad Reguladora de los Servicios Públicos  
Legislative Authority for Public Services |
| AyA          | El Instituto Costarricense de Acueductos y Alcantarillados  
The Costa Rican Institute of Aqueducts and Plumbings |
| CICA         | Centro de Investigacion en Contaminacion Ambiental  
The Centre of Investigation in Environmental Contamination |
| ESPH         | Empresa de Servicios Públicos de Heredia  
Office for Public Services for Heredia |
| INTA         | Instituto Nacional de Innovación y Transferencia en Tecnología Agropecuaria  
The National Institute of Innovation and Transfer of Agriculture and Cattle Technique |
| MAG          | Ministerio de Agricultura  
Ministry of Agriculture |
| MS           | Ministerio de Salud  
Ministry of Health |
| MINAE        | Ministerio del Ambiente y Energía  
Ministry of Environment and Energy |
| UNA          | Universidad Nacional  
National University |
| UCR          | Universidad de Costa Rica  
University of Costa Rica |
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1 INTRODUCTION

1.1 Introduction
Costa Rica has an abundance of fresh water which can be used for irrigation, hydropower and as drinking water. This unfortunately does not mean that Costa Rica always has a drinking water of good quality. Costa Rica is a country with fast growing infrastructure and sometimes the environmental regulations are disregarded\(^1\). Concern regarding quality and quantity of drinking water is common in media as well as among the Costa Rican people. Almost everyday articles are published in local newspapers, such as la Nacion and al Día, concerning treatment, contamination or costs of the water. One of the most commonly discussed issues is pollution of waters with nitrates and nitrites from fertilizers used in coffee plantations in the Central Valley, Costa Rica. As nitrates and nitrites cannot be detected by a change of flavour or colour of the water it can be a silent threat to human health. High concentrations can cause oxygen deficiency in the blood, metahemoglobinaemia, in infants and increase the risk for gastric cancer\(^2\).

1.2 Purpose
The purpose of this project was to investigate how contamination from fertilizers for coffee plantations affects the uses of and the costs for domestic water in one part of Costa Rica. The investigation was made out of two perspectives. One of the perspectives was to analyse water samples to investigate if water from an area connected to a coffee plantation had higher concentrations of nitrate and nitrite compared with water taken from an area where fertilizer use is not as intense. The water quality in terms of other physical and chemical characters such as pH value, turbidity, conductivity and colour was also investigated to get a better understanding of the water quality in the areas in general.

The other perspective was to investigate the knowledge of the existing problem and the interest to make a change and improve the water quality among people in the nearby area. Through a survey of in-person interviews a willingness to pay, WTP, to get an improvement of their domestic water, was estimated. The willingness to pay estimation is in this case a

\(^2\) Ibid.
measurement to see how much the population is willing and able to sacrifice to get a better quality of their drinking water.

1.3 Method
Through contact with Bernardo Mora Brenes at The National Institute of Innovation and Transfer in Agriculture and Cattle Technique\(^3\), INTA, San José, Costa Rica, a project about nitrates and nitrites in drinking water was discussed. Analyses of nitrates and nitrites are relatively easy to make and high concentrations can indicate that other substances, potentially more toxic, are present.

The interviews are based on a method called the Contingent Valuation Method, CVM. A cost-benefit analysis of the current contamination problem is a method to understand if an improvement of the environment is motivated or not. Investigation of the willingness to pay may be useful in this decision making process. A remark is that this paper does not further investigate cost-benefit analysis. The material from the interviews was also used to show whether there are any correlations between the WTP and variables asked for, for example age, income or education of the respondents.

1.4 Disposition
The essay begins with a chapter regarding information of Costa Rica and current management and media cover of domestic water. Chapter three covers background of environmental valuation, willingness to pay and the contingent valuation method. Theory of coffee fertilization and effects of nitrate and nitrite, drinking water regulations as well as theory of the contingent valuation method is covered in chapter four. Chapter five includes methods for the water sampling, the interviews and the statistical analysis of the interviews. In chapter six results from the water analysis and the willingness to pay adhered from the interviews are gathered followed by a discussion in chapter seven.

\(^3\) For translation see Abbreviations.
2 THE CURRENT SITUATION OF DOMESTIC WATER IN COSTA RICA

2.1 Costa Rica

Costa Rica has its borders to Nicaragua in the north, Panama in the south, the Caribbean Sea in the east and the Pacific Sea in the west. For a map of Costa Rica see Figure 1. The land territory is 51 100 km² which is divided in seven political zones. Costa Rica has about 4 000,000 inhabitants. Costa Rica can also be divided in climate zones, see Figure 2. The country in general has three different climates, humid tropical areas at an altitude of 0-600 m, subtropical in the areas at an altitude of 600-1600 m and cold climate in the areas with a higher altitude than 1600 m.

The investigation was made in the Central Valley which is situated in the middle of the country and surrounded by volcanoes. This area has a climate with a mean temperature of 21.6 °C and a rain period from May until November. Precipitation in the area is over 3,000 mm per year.

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4 http://www.equus-ole.com, 01/03/2006
6 www.fao.org, 03/02/2005
Figure 2. Map over climate zones in Costa Rica.7

The Central Valley only occupies about six percent of the land area but nonetheless about two thirds of the population inhabits the area. The capital San José and the major cities Alajuela, Heredia and Cartago are situated in the Central Valley. Major land use in the Central Valley is agriculture as the volcanic soils are suitable for cultivation.8 Present cultivations are for example coffee, sugar canes and vegetables as chayote. The majorities of the soils in the Central Valley are highly permeable and well structured Andisols. These soils usually have a high rate of annual run off, >1000mm.9

The water samples were taken in two areas situated north of Alajuela. The interviews were primarily made in Alajuela. Alajuela is Costa Rica’s second biggest city and it is situated about 10 km north west from San José. Alajuela has about 35 000 inhabitants.10 For location see Figure 1.

2.2 Coffee cultivation in Costa Rica

About 108,000 ha of land are used for coffee cultivation in Costa Rica. Areas where coffee is grown are, Alajuela, Heredia, San José, Cartago, Turrialba and Perez Zeledon. After bananas, coffee is the most important export good and after tourism and bananas the most important foreign exchange in Costa Rica. There are about 65,000 coffee farms in Costa Rica and a major part of them are small farms. Many of these coffee farms are situated in the Central

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7 http://www.travelexcellence.com, 01/03/2006
10 McNeil, p. 22.
Valley as fertile soils from the volcanoes are present in the area. The soil has enough organic matter and a good drainage. Coffee can be cultivated in the sun or in the shade. In the Central Valley the shade grown coffee plantations are very rare. The rich soils and the altitude are understood as giving a coffee with a good quality without having trees included in the cultivation. Cultivation without shade trees usually has higher input of fertilizer. These monocultures usually have a high rate of erosion as heavy rains are common in these areas.

The coffee bushes flower for a couple of days with white flowers. The fruit is green until maturity when it turns red. The fruit which is oval and about 10-20 mm contains the bean. The beans are separated from the pulp after harvest and are dried before roasting. A coffee bush can be productive for about six to ten years.

2.3 Management of domestic water

The applicable law concerning conservation and management of water sources in Costa Rica is the General Water law No 276, which was introduced in 1942. Since then the country has evolved in terms of a rapid industrialisation, urbanisation, an increased population and a large tourist sector. The land use and the infrastructure have also changed. Sources of pollution have increased. These changes all affect the water resources and make the law out of date. The current law does not give a good legal ground for protection and conservation of the raw water used for drinking water production. A new water law is therefore under discussion. Lack of good planning of areas that should be protected for giving water with a good quality is also apparent. Loss of areas covered with vegetation is a result of the lack of planning of urban areas.

There is also a lack of coordinated institutional work and administration of the water management. At least fifteen institutions work with water regulations which have been proved to give a decentralised and inefficient work. Some areas are covered by regulations from more than one institution whereas others are not covered by regulation at all. Following are some of the institutions that work with water questions in Costa Rica.

12 http://www.incae.ac.cr, 01/03/2006
13 Janzen, p.86-88
14 Astorga, p.17-25.
15 Jiménez, Roberto, Agua, Legislación y Rectoría Estatal (Heredia:Ciencias Ambientales, 2003) p. 49-56
16 www.incae.ac.cr, 01/03/2006
17 For translations see Abbreviations.
- MINAE – declare areas to be water protection areas
- Ministerio de Salud – controls contamination of water
- MAG – controls contamination of waters in zones with irrigation
- ARESEP – sets water tariffs
- Municipalities – control contamination of and use of public waters, can be owners of an area used as a water source
- AyA – sets norms for and plans use of public water

Lack of technical knowledge, the monitoring of quality and quantity of the water and financial resources are also common within the institutions. How the institutions that regulate water use and protection of water are supposed to work needs to be included in the new law.

The providers of drinking water also work in different areas and at different levels which leads to a decentralised administration of drinking waters. Of the 97% of Costa Rica’s inhabitants that have access to drinking water, 43% received their water by AyA, 24% from associations of users, 16% from the municipalities, 5% from ESPH and 9% from private wells or common sources. From these providers not all water followed the norms of quality for safe drinking water. For example only 10% of the water distributed by municipalities has a quality regarded as a safe drinking water.

Regarding used household water only 2% of the water receives a sanitary treatment. 21% of the population is connected to a public plumbing system and 69% use septic tanks. A problem with the use of septic tanks is that they can leak untreated water. About 10% of the population has other systems of disposition.

One of the most discussed problems with drinking water quality in Costa Rica is the leaching of nitrates and nitrites from fertilization of different cultivations or leakage from septic tanks. One area that is especially threatened by this is the Central Valley, which is surrounded by a

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18 www.ifam.go.cr, collected 01/03/2006
19 Jiménez, p.49-56.
20 For translation see Abbreviations
21 For translation see Abbreviations
22 Astorga, p.17-25.
23 Jiménez, p.49-56.
large amount of coffee plantations along the sides of the volcanoes that surround the San José area.\textsuperscript{24}

A problem with the protection of a watershed can be to keep human presence out from the area, especially if the area is privately owned. An area within 100 m radius from the watershed should be protected from all human presence and if the area needs a reforestation it shall be done. In a 200 m radius from the water source human presence can be allowed, but only in terms of for example an organic cultivation without fertilizer input. If the land is privately owned a permit to enter the grounds is required and actions can be taken if the land owner is not willing to agree to new conditions.\textsuperscript{25}

The Municipality of Alajuela has begun a campaign to make inhabitants living in the area of a water source understand the need of keeping the source free from contamination. The Municipality is also working with enclosing some of the water sources as well as informing the inhabitants by adding information signs on the site.\textsuperscript{26}

2.4 Media cover of water questions in Costa Rica

The media coverage concerning water quality and access to water has been abundant. Some examples of articles published during year 2005 in Costa Rica are \textit{CNE is asking to declare an emergency of contaminated water}\textsuperscript{27} and \textit{214 families in Orotina receives water with clay}\textsuperscript{28}. The articles describe situations more or less threatening of the quality of drinking water. The first article mentions that combustibles have been found in an aquifer supporting about 320,000 persons southeast of San José. The second article describes how people in Orotina, which is part of Alajuela, could not use or drink the water that they paid for as the water was brown of clay. An ongoing debate exists concerning the costs and prices of water in Costa Rica. For example an article in the TicoTimes mentions that a decree signed by the minister of environment and energy will increase the costs for use of water up to 80 times. Through defining a value of water as a raw material the natural resource could be protected. This could

\textsuperscript{24} Material from the seminar
\textsuperscript{25} Interview with Félix Angulo from the Environmental Department at the Municipality of Alajuela
\textsuperscript{26} Ibid
\textsuperscript{27} Esteban Oviedo, CNE pide declarar emergencia por contaminación de agua, (San José:La Nacion, 2005).
\textsuperscript{28} Jorge Umaña, 214 familias de Orotina reciben el agua con barro, (San José:La Nacion, 2005).
be a way to pay for the environmental service and the increased income can be used to protect the water resources.  

29 The decree has still not been signed by the president Abel Pacheco.  

On September 22, 2005, the Tribunal Latinoamericano del Agua hosted a seminar in San José about contamination of drinking water by nitrates and the media response to this problem. The name of the seminar was: *Vulnerability and Risk Associated with Contamination of the Subterranean Waters of the Barba Aquifer*.  

31 During the seminar different views of water contamination with nitrate and nitrite were presented by water distributors and scientists.  

3 ENVIRONMENTAL VALUATION  

Environmental valuation is used to compare the value of an environmental change to the existing situation. The basic strategy for valuation is to treat the environmental services impacted as arguments in household utility functions, as commodities. The information from a valuation of the environment is thus useful prior to making decisions regarding future changes. One example, as in this case, is to examine which benefit can be received by putting a price tag on a decreased nitrogen contamination. The advantage of an improvement of the water quality has to be compared to the advantage of having the same level of contamination as before. This means keeping the same coffee production. An environmental valuation is not the only information needed to make the final decision about the contamination issue but the valuation can provide an interesting material for an analysis of a project’s advantages and disadvantages in a social welfare perspective.  

The first step to analyse a project’s social economic consequences is to estimate the effect in physical terms. The second step of the analysis is to set the effects of the project on a value scale, in purpose to show how different choices about the project will give different results. For example if the contamination is stopped the value would be zero. On the other hand the

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29 Rebecca Kimitch, Water Law Breaks New Ground, (San José:Tico Times, 2005)  
30 For interest of the articles see Appendix 5.  
31 A translation of: Vulnerabilidad y Riesgo Asociados a la Contaminación de las Aguas Subterraneas del Aquífero Barba. Speakers in the seminar was Dr. Jenny Reynolds-Vargas from the Universidad Nacional Costa Rica, Dr. Darner Mora Alvarado director of AyA, Luis Ganes from ESPH and Isabela Román from Proyecto Estado de la Nacion.  
32 See Appendix 1 for further information about the seminar.  
33 Chapter 3 is based on Runar Brännlund, Bengt Kriström, Miljöekonomi (Lund: Studentlitteratur, 1998), chapter 3 and 4.  
34 Perman et. al. Natural Resources and Environmental Economics (UK: Pearson Education Limited, 2003), p.402
level of contamination could be halved or allowed to remain as it is currently, where the latter choice would give a maximum value. It is preferable to choose the project with the largest increase of welfare. This is where the willingness to pay gets interesting as welfare changes and willingness to pay are closely linked. The third and the last step are to choose between different projects. A common decision rule is to pick the project that gives the highest social economic gain when the sum of the willingness to pay is compared with the total costs for the project. It is not a flawless decision criterion, for several reasons; one is because it does not answer the question how the welfare should be shared.35

3.1 Willingness to pay
The purpose of measuring willingness to pay is to measure a change in welfare. A change in welfare is not observable because it is built on the individual’s subjectively experienced utility. The willingness to pay for a good would be revealed in a perfect market economy by the market price, as it is possible to interpret the price as the marginal willingness to pay to get one more unit of the good. The price is a monetary measure of the welfare in the sense that it measures and is proportional to the individual’s marginal utility of buying one more unit.36

The willingness to pay for non-market goods can be explained by monetary welfare measurements, which is described in the next section.

3.2 Monetary welfare measurements, Compensating Variation and Equivalent Variation
To understand the valuation methods to be used here, it is useful to introduce two concepts. Compensating Variation, CV and Equivalent Variation, EV. Compensating Variation, is a measurement of how much a person is at maximum willing to pay to get an improvement of the environment without lowering her well-being. Equivalent Variation, is a measurement of how much a person at minimum is willing to accept to compensate that the environment is going to stay the same. To explain how Compensating Variation and Equivalent Variation are connected to willingness to pay it is easiest to look at a project example, where $x$ is an environmental index and the environmental quality is going to change from $x$ to $x_1$. An individual’s preferences can be represented by a utility function with two arguments:

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35 Brännlund, Kriström, p. 63-65.
consumption (=income), q, and environmental quality, x. The utility function \( U(q, x) \) describes how the individual apprehends different combinations of consumption and environmental quality, assuming that the individual gets a better economic standard if the consumption increases, at any given level of x.

Assume that the individual’s income does not change because of the project. In this case q will not be affected. This gives a change in utility equal to \( U(q, x_1) - U(q, x_0) \), if the project is undertaken. As the utility can not be measured the question is how to measure the welfare change. If the individual increases her well-being, the utility change is positive, i.e. \( U(q, x_1) - U(q, x_0) > 0 \). If an individual is prepared to decrease her income to get an environmental quality change, she pays A SEK and the project carries through, and \( q - A \) SEK is left for private consumption. The new environmental quality is \( x_1 \). The subjectively experienced utility is \( U(q - A, x_1) \), and as long as \( U(q - A, x_1) > U(q, x_0) \), she thinks that it is worth spending \( A \) SEK on the quality improvement. The willingness to pay for changing from \( x_0 \) to \( x_1 \) corresponds to the maximal amount of money she is willing to give up receiving the change. It is a sum, CV that corresponds to \( U(q - CV, x_1) = U(q, x_0) \). CV specifies how much the individual maximum can pay without getting worse off.

If, on the other hand \( x_1 \) is chosen as starting-point then EV corresponds to the smallest compensation that has to be given to the individual that makes her accept giving up the environmental quality increase. This sum is defined by equality \( U(q, x_1) = U(q + EV, x_0) \). As mentioned before the initial income is assumed not to change because of the project and the starting points are therefore a horizontal line. See figure 6. The indifference curves describe the combinations of consumption and environmental quality that the individual thinks are equivalent. If x increases from \( x_0 \) to \( x_1 \), the utility level equals \( U_2 \). The vertical distance between the indifference curves correspond to the utility change.
Figure 6. CV corresponds to the amount of money the individual is prepared to pay, given that she gets the environmental change $x_1$ without decreasing her utility $U_0$. EV implies the amount of money that has to be compensated to the individual if the environment is going to stay the same with a contamination or if it is going to decrease the quality and make the budget restriction increase so she has the same utility as in point $x_0$.

In the literature it is often written that the maximal willingness to pay and the smallest compensation demand should be equal. This makes it easier to decide which method is going to be chosen as it does not matter. But it has been observed that there are differences in practice. An explanation could be that it is more difficult to formulate a compensation question so that the individual reveals the smallest amount of compensation. It is therefore common that the environmental quality gets exaggerated.

The sum of the willingness to pay over all affected individuals is often compared to the costs to go through with a project. If the sum covers the costs the project is considered as socially-economically profitable. A critique against this method is that the compensation is hypothetical; it is not going to be realized. The idea is to identify potential profitable projects and transfer the income distribution to the Government. The sum of the willingness to pay for a given project is depending on the income distribution in the society which makes it important to as far as possible analyse and explain how different groups in the society get affected by a project and not be satisfied by comparing the sum of the willingness to pay with
the costs. The following sub-section in general terms describes the method that has been chosen to estimate the WTP, the Contingent Valuation Method.

3.3 The Contingent Valuation Method

There are two types of methods to convey environmental valuations, the direct and the indirect method. The direct method is based on interviews, with direct questions about willingness to pay. The indirect method is using already existing connections between environmental quality and some market priced goods. One advantage of the indirect method is that it is based on the people’s actual behaviour. One disadvantage is that it is impossible to estimate existential values. The contingent valuation method is a direct method and is the method that is used in this project.

The contingent valuation method was developed in 1940 in USA but it took several years before it was internationally known. The first applications in Scandinavia are from the early 1980s in Norway. At the end of the 1980s the popularity of the method had grown drastically and was now the dominating method of environmental quality valuation. The method is often used for environmental issues but also in other applications, for example health economics.37

4 THEORIES

4.1 Nitrogen

4.1.1 Nitrogen in fertilizers

Nitrogen is crucial for the coffee plant as it contributes to the leaf growing, the chlorophyll molecules and enzymes. If nitrogen is deficient the plant will show chlorosis, yellow leaves, as it can not use the energy from the sun. The adding of nitrogen gives the best production response. Recommended for coffee production is about 300-350 kg/ha/year of nitrogen applied at two or three occasions per year. Normally a fertilizer that includes other substances that the coffee plant could require is applied twice a year with the first occasion at the beginning of the wet period. Other substances required in coffee fertilizer are potassium, magnesium, phosphorus, calcium, zinc and boron. An extra fertilization with only nitrogen is normally added at the end of the rains.38 For a good response from the fertilizer it is supposed

37 Brännlund, Kriström, p. 101-102
38 www.icafe.go.cr, 04/02/2005.
Nitrogen in fertilizer is normally added in form of ammonia, NH$_4^+$, and nitrate, NO$_3^-$, where ammonia is the first transformation from organic nitrogen. Nitrate is an inorganic form of nitrogen. The transformation from ammonia to nitrate goes through the formation of nitrite, NO$_2^-$ which is an unstable form. This can be performed naturally by bacteria in the soil where the ammonia is first oxidised to nitrite and then to nitrate.

Ammonia is retained by the soil as soil particles have a negative charge. Nitrogen in form of nitrate on the other hand is negatively charged just as particles in the ground, which leads to the leaching of nitrate to surrounding water. Both forms are soluble in water. Nitrate is the chemical form of nitrogen that is easiest absorbed by the plant.

Investigations have shown that concentrations of nitrate in soil can vary seasonally. Soil NO$_3^-$ accumulated in the soil during the dry season and was reduced during the wet season. Soil NO$_3^-$ is believed to be reduced because of a higher rate of root uptake, leaching and possible denitrification during the wet season. Allophanous Andisols that are frequent in the Central Valley are believed to be able to absorb relatively high contents of NO$_3^-$, especially at a low pH, but high input of fertilizer and liming of coffee soils reduce these effects. Leaching of NO$_3^-$ is also affected by organic matter, cation exchange and competing anions in the soil. Soil moisture can also control mineralization and nitrification, but the process in the Central Valley has not been studied properly.

One of the existing problems with a successful fertilization of coffee is that usually only about 30 % of the nitrogen applied is absorbed by the plants. The rest of the nitrogen in form of ammonia accumulates in the soil and gradually turns to nitrate and leaks to surrounding waters or goes to the atmosphere in form of N$_2$. The formation of N$_2$ gives an acidification of the soil. The nitrate that leaks out to surrounding water can have several negative consequences. As nitrate is a nutrient that plants use for growth this is also the case for plants

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39 Interview with Oscar Gonzales Rodrigues, 06/10/2005.
40 [http://www.mirat.net](http://www.mirat.net), 01/03/2006.
41 Reynolds, p. 289-299.
that grow in the water. This leads to eutrofication and oxygen deficient waters. Nitrate in water used for drinking water can also have health effects for humans. It can take time for nitrogen to move from soil to groundwater and for increased concentrations of nitrates to appear in aquifers.

In order to avoid leaching of nitrogen to surrounding water several measurements can be done. By soil and plant analysis the amount of fertilizer used can be regulated better. Realistic goals for the yield can also keep levels of fertilizer used down. Application of fertilizer should also be varied within the field after varying topography, soil type and age of the coffee plant. Fertilization covers about 10% of the production cost, another reason to adjust the amount used. A way to stop nitrates from reaching surrounding waters could be to have ditches around the plantation with nutrient absorbing plants. Instead it is usually recommended that weed should be controlled before fertilization is added to avoid that nitrogen added goes to these plants instead which makes land owners “clean” areas as ditches from grass as they see it as weed. This makes the run off water going straight to surrounding waters.

**4.1.2 Nitrate and nitrite and the effect on human health**

Absorbed nitrite can be oxidised to nitrate in the blood during the transformation of Fe⁡²⁺ in the blood to Fe⁡³⁺. Fe⁡³⁺ is a chemical form of iron that cannot transport oxygen. The condition metahaemoglobinemia can appear which can lead to cyanosis. Most affected are infants and pregnant women.

Nitrite can also react with compounds in the human stomach and form N-nitroso compounds that can be carcinogenic. The correlation of high concentrations of nitrate in drinking water and gastric cancer can not be excluded. Another health implication due to high concentrations

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44 [www.who.int](http://www.who.int), 12/02/2006
45 [www.aces.edu](http://www.aces.edu), 02/02/2005
46 [www.aces.edu](http://www.aces.edu), 02/02/2005
47 Personal contact with Carlos Hidalgo at INTA
48 [www.who.int](http://www.who.int), 12/02/2006
of nitrate in drinking water can be the swelling of the thyroid gland in the front of the neck.\textsuperscript{49} The thyroid gland is included in the metabolism process in the human body.\textsuperscript{50}

Formation of nitrite can appear when a drinking water is chloraminated as small amounts of ammonia present can be oxidised to nitrite. This decreases levels of disinfectants and increases the amount of ammonia oxidation bacteria.\textsuperscript{51}

4.2 Drinking water regulations

Recommendations for the quality of drinking water in Costa Rica follow Decrete 32327-S MINAE Regulations for Drinking Water Quality\textsuperscript{52}. See table 1 for recommended and maximal values of substances and physiological characteristics analysed in this project.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Recommended value</th>
<th>Maximal value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate [mg/l]</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Nitrite [µg/l]</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>pH</td>
<td>6.5</td>
<td>8.5</td>
</tr>
<tr>
<td>Turbidity [UNT]</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Conductivity [µS/cm]</td>
<td>400</td>
<td>-</td>
</tr>
<tr>
<td>Colour [mg/l]</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

**Table 1. Recommended and maximal values for analysed substances and physiological characteristics.**

pH value is measured to examine the acidity of the water. At low pH values corrosion of pipes and tubes can occur which can release metals in the water. pH values over 10.5 cannot be used as drinking water as it can affect mucous membranes and eyes. Turbidity is a measurement of particles in the water and high levels show that particles can be present in the water. Conductivity is a measurement of salt in the water. High levels can indicate that chloride can reach the water from drains or wastes. It can also affect corrosion of tubing. Coloured water can appear if iron or organic material is present in the water. Abnormal changes of colour can indicate abnormal levels of these or other substances.\textsuperscript{53} For effects on human health from nitrate and nitrite in drinking water see section 4.1.2.

\textsuperscript{49} [www.who.int](http://www.who.int), 12/02/2006
\textsuperscript{50} [www.patient.co.uk](http://www.patient.co.uk), 01/03/2006
\textsuperscript{51} [http://www.h2o4u.org](http://www.h2o4u.org), 01/03/2006.
\textsuperscript{52} A translation of: Decreto 32327-S MINAE Reglamento para la Calidad del Agua Potable.
\textsuperscript{53} [www.sos.se](http://www.sos.se), 01/03/2006.
The following section explains the theory of the Contingent Valuation Method and how to perform a CVM survey.

4.3 Theory of the Contingent Valuation Method

The contingent valuation method is used to estimate economic values for all kinds of ecosystems and environmental services. It can be used to estimate both use and non-use values and it is the most widely used method for estimating non use values. Use value is the benefit accruing from use of the resource and non-use value is the value a consumer attaches to a resource independent of her use of it\(^{54}\). The method involves directly asking people, in a survey, how much they would be willing to pay, WTP, for specific environmental services. The contingent valuation method is a “stated preference” method which means that it asks people to directly state their values in contrast to the “revealed preference” method which lets people reveal a value by actual choices.\(^ {55} \)

4.3.1 Application of the Contingent Valuation Method

The CVM is based on an accurately structured interview where the respondent is introduced to a specific change. A strategy of how to make the interview is presented in different phases below.

- Define the valuation problem, including what services are being valued and which the relevant population is. It is important to define the change that is going to be valued as exact as possible. It will then be easier for the respondent to understand and value. To make the survey as useful as possible it is important that following criteria are fulfilled:
  - Theoretical consistency
  - Relevant for the policy
  - Credibility
  - Easy to understand

It can also be important to examine which means of payment that would be used in the process to change the environment. Examples could be raising the tax or paying a


\(^{55}\) [www.ecosystemvaluation.org](http://www.ecosystemvaluation.org), 17/02/2006.
fee as a lump sum. It is of importance to notice that different mean of payment can give different answers.\textsuperscript{56}

When a project generates indirect effects on health for example it is almost impossible to know how and whom it will affect. Most of the times it is enough to estimate probability distributions for health risks related to changes of contamination.\textsuperscript{57} In order for the questions to be effective, the respondent must believe that if the money were paid, whoever was collecting it could effect the specified environmental change\textsuperscript{58}.

As written earlier it is possible to use both CV and EV to measure a change in welfare in monetary terms, but the theory does not say anything about whether to use willingness to pay or willingness to accept, a minimum compensation that you are willing to accept to let an environmental pollution keep on polluting.

Questions can be asked in a variety of ways, using both open-ended and close-ended formats. In the open-ended format, respondents are asked to state their maximum willingness to pay for the environmental improvement. With the close-ended format, also referred to as discrete choice, respondents are asked whether or not they would be willing to pay a particular amount for the environmental improvement, or whether they would vote yes or no for a specific policy at a given cost.

- Make decisions about the survey itself, whether it will be conducted by mail, phone or in person, how many interviews that will be conveyed, who will be interviewed and other related questions. These questions are depending on things like the importance of the valuation issue, the complexity of the question being asked, and the budget constraint. In-person interviews are to prefer and are most efficient when dealing with complex questions, because of the ability to explain the issue. On the other hand the respondents’ answers can easily get affected in an unwanted direction. Although in-person interviews are considered to be the most expensive type of survey they are more useful because it has been shown that the respondents are more likely to complete a long survey when they are interviewed in person, than by mail or phone.

\textsuperscript{56} Brännlund, Kriström, p. 102.
\textsuperscript{57} Brännlund, Kriström, p. 102.
\textsuperscript{58} \url{www.ecosystemvaluation.org/contingent_valuation.htm}, 17/02/2006.
The amount of background information that the method requires can also affect which type of interview that is to prefer. The CV method requires relatively much background information and it is relatively difficult to use phone surveys even though it may be less expensive.\footnote{Brännlund, Kriström, p. 112.}

- Design the survey. This is the most difficult and time-consuming step but also very important. It is common to start with initial interviews and/or focus groups with questions about peoples´ understanding of the issue related to the situation, whether they are familiar with it, whether and how they value this problem and the habitat services it provides. This will help to develop and clarify specific questions for the survey, as well as decide what kind of background information is needed and how to present it. To use photos, drawings or even videos in the background information is preferable if it makes it easier to understand the issue of the survey. When it comes to questions about willingness to pay for an environmental change it is important to remind the respondents to consider their budget constraints, so they do not exaggerate the amount of money or the other way around.\footnote{www.ecosystemvaluation.org, 02/02/2006.}

After the focus groups and when the background information is collected a pre-testing survey is a good thing before the real survey that is going to be used statistically. The purpose is to see if the respondents understand the survey and let them ask questions if anything is confusing.

- The survey implementation. In-person surveys may be conducted with random samples of respondents, or “convenience” samples may be used – asking people in public places to fill out the survey.

- Compile, analyze and report the results. The data must be entered and analyzed using statistical techniques appropriate for the type of question.\footnote{www.ecosystemvaluation.org, 02/02/2006.}
4.3.2 Advantages and limitations of the Contingent Valuation Method

The aim with this subsection is to give information about some of the advantages and problems that can come up while working with environmental valuation and the contingent valuation method.

Environmental valuation is relatively often criticised on the grounds that the environment has an infinite, immeasurable value, which can not be measured in money. But money is only used because of the comparison convenience, using the wide understanding of it. As long as the same unit is kept it is possible to use any measure that is preferable for the project.62

The advantage of a CVM is that it is a flexible method that can measure almost anything. Even if the research for the project has to be precise and is rather difficult, the analyses of the results are not that complicated. It is often enough to use the mean or the median value per capita, per household or an aggregated value for the affected population.63

The disadvantages with the CVM are that most people are unfamiliar with placing monetary values on environmental goods or services and may not have an adequate basis for stating their true value. Experiences show that the respondents sometimes answer the wrong question. They may express a positive willingness to pay because they feel good about the act of giving for a social good, also called the “warm glow” effect, although they believe that the good itself is not that important. The respondents may also state a too high WTP to emphasise that they are positive to improvement of the environmental quality in general. It sometimes happens that the respondent adds another perspective to the WTP that the researcher had not intended. For example, if asked about their WTP for improved visibility, through reduced pollution, the respondents may include the health risk in the valuation. Different means of payment could give different WTP. The respondents may state a lower WTP if a tax is going to be used just to protest about the increased tax.64

Although it might seem like it is too difficult to make a valuation of the environment with a good precision, it is necessary to compare the advantages with the disadvantages of not going through with it. It is a bigger risk to overexploit a natural resource if no valuation has been

62 Brännlund, Kriström, p. 66.
63 www.ecosystemvaluation.org, 02/02/2006.
64 www.ecosystemvaluation.org, 02/02/2006.
done. The value of the good can also be considered as zero if it has not been valued, which could be misinterpreted.

5 MATERIAL AND METHODS

5.1 Material and method

The two areas where water samples were taken, La Fuente and Los Chorros, are both situated in the Central Valley. La Fuente provides drinking water for Alajuela, distributed by the Municipality of Alajuela. Los Chorros provides drinking water for Atenas and Orotina, situated southwest of Alajuela, distributed by AyA. For location of the cities see Figure 4. These areas were chosen after discussion with Bernardo Mora Brenes at INTA. He has a good knowledge of water distribution and land use in the area and identified these sources as important drinking water sources for the people in the province as well as areas with different land use. For more information of precipitation and temperature in the areas see section 2.1.

Figure 4. Map over the Central Valley with two arrows indicating the approximate situation of the areas where the water samples were taken.  

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65 www.guiascostarica.com, 01/03/2006
5.1.1 La Fuente

The coffee plantation La Pequeña, San Isidro, Alajuela, is situated in a valley. For a map over the area see Appendix 6. La Fuente is a groundwater source for drinking water situated in the middle of the coffee plantation.

It is the Municipality of Alajuela that is responsible for the water quality, as well as the protection, of this watershed. The only treatment that the water receives before use is chlorination. The Municipality of Alajuela are working in the area cleaning the tank where chlorination is made and to secure that people or animals cannot get access to the water.

History of the area was received from an interview with Oscar Rodriguez Gonzales who has been managing the coffee plantation for twelve years. La Pequeña has been managed as a coffee plantation since 1983 and the farm is about 11 manzanas, mz. As one manzana is approximated as 0.7 ha the farm is approximately of the size 7.7 ha. The coffee type used in the area is called *Arabica Caturra*, which is a high quality coffee that might have a lower production than other types of coffee cultivated in the country.

Fertilizer is applied three times a year in May, August and November. About 60 g of fertilizer is applied per adult bush and there are about 5,850 bushes per ha in this area. This gives that the applied fertilizer added per occasion measures about 350 kg/ha and about 1050 kg/ha/year. The fertilizer used in La Pequeña contained 18% nitrogen, 5% of phosphor added as P2O5, 15% of potassium added as K2O, 6% magnesium added as MgO and 2% of boron added as B2O3. This gives an amount of about 63 kg N/ha added per fertilization occasion which gives about 189 kg N/ha/year.

5.1.2 Los Chorros

The second area from where water samples were taken is situated in the national park, Los Chorros. The park is situated in an area called Tacares de Grecia north of the town Grecia. For location see Figure 4. The park is used as a recreation area. The area is surrounded by cultivations of different vegetables and sugar canes. The spot was chosen to compare the

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66 For photos of the coffee plantation see Appendix 2.
67 Altitude at this spot is approximately 1270 m above the sea and N 10° 0.4 min 34.3 sec and WO 34° 11 min 17.7 sec. Error 12m.
68 Interview with Felix Angulo, 21/10/2005.
69 One manzana give about 60 fanagas, fa of coffee which is approximately 400 l of coffee beans.
concentrations of nitrates and nitrites in water with the concentrations from La Fuente as cultivation of vegetables is not as fertilizer intense as coffee plantations. The spot was also chosen since water is taken for use as drinking water distribution for Orotina and Atenas.

Water from the area is managed by AyA who collects surface water flowing down a mountain. Their tank is situated in a confined area and the water for the samples was taken from the excessive surface water flowing outside the tank. The excessive water runs down to a river that runs through the park. The river is connected with water from two waterfalls in the area.

5.2 Procedure for the water sampling
Once a week during seven weeks water samples were collected in the two areas chosen for analysis of nitrate and nitrite concentrations in water. At two occasions pH, temperature, conductivity, turbidity and colour were also analysed. The water for analysis of physical and chemical characters was collected in an empty and cleaned 1.5 l pet bottle. The water for analysis of concentrations of nitrate and nitrite was collected in brown bottles as light affects the chemical transformation of nitrogen. The nitrate sample was collected in a 500 ml bottle and the nitrite sample was collected in a 125 ml bottle. Before any water was taken the bottles were cleaned three times in the water examined. To the water sample for nitrite analysis eight drops of chloroform were added. A blank sample with distilled water was also brought from The Centre for Investigation of Environmental Contamination, CICA. The bottles with the blank samples were opened for about a minute in the area to see if the air affected levels of nitrate or nitrite. After collection the bottles were marked and guarded in an icebox and brought to a refrigerator kept at 4°C at the laboratory at CICA, at the University of Costa Rica. The nitrates were analysed with ionic chromatography and the nitrites with UV-visible spectrophotometry. The methods used by CICA follow Standard Methods for the Examination of Water and Wastewater.

5.3 Method of the interviewing
The contingent valuation method was chosen because it is a relatively easy method to accomplish as the aim was to find a method to measure the use value of domestic water.

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70 For photos see Appendix 2.
71 For translation see Abbreviations.
The reason to choose in-person surveys was that the other survey techniques would have brought too many difficulties. The city of Alajuela is a suburb to the capital San José of a relatively small geographical area. In-person interviews were chosen instead of phone or mail interviews for the possibility to have an open discussion while interviewing and to see the reaction to the questions and also for the possibility to easily answer any questions about the interview. Another reason was the possibility to get a large diversity of people. The ability to select respondents with different sex and age is easier with in-person interviews.

5.3.1 The interview

To design the interview Luis Alpizar and Bernardo Mora Brenes who lives in the area and have knowledge of the land and water use in the area helped us. They became the focus group for the development of the interview. Even though they are not economists they knew how to express the situation and compile the questions so that it would be easy to understand for the respondents.

The background information explained the current situation of contaminated water that can cause problems regarding the human health. Continuously the information described how an increased amount of money that the people are willing to pay for the water will be used to develop better sanitation and for recreation and rehabilitation.

The questions in the interview were separated into three parts. The first part contained background questions, for example if the respondent receives water in the household and who the distributor is, if they have had any problems with the water etc. The second part included more direct questions about how much they pay at the moment for the water, how much water they consume and if they were willing to pay more for receiving water with higher quality and, if so, how much they are willing to pay. The third part was strictly socio-demographical questions about the respondent and his/her household.73

The first day about 60 pre-starting interviews were made. Certain absences of information and incomprehensible questions were easy to discover. A few different methods of interviewing was tried out to see which fitted best, to get the best results and to get as many completed

73 See the entire interview in Appendix 3.
interviews as possible. The most important but also most difficult question to answer was the question of willingness to pay. The first attempt was that the respondent should answer yes or no if they are willing to pay more for a better water quality. If they answered yes they should also indicate the amount of money they are willing to pay per month. The problem became that most of the respondents answered yes or no but did not bother to estimate an amount of money that they were willing to pay. In a second attempt to really show which questions that are most important the questions were underlined. The attempt with underlined questions did not succeed satisfyingly. Even though the actual interviews were begun it was necessary to add five alternatives of willingness to pay amounts. When the respondents got the alternatives to choose from it went much easier, more respondents thought about an alternative and picked one.

To have a large diversity of respondents the interviews were performed in different places and during the whole day when the sun was up. The interviewing started in a residential district, the idea was to make random samples of respondents from a number of places in the area, but because it was during the day just a few people were at home and they were only from one social-demographic group, housewives. Instead convenience samples were used, at the central bus stop in Alajuela and in a park in the centre of the city. This method had the advantage that it was done a lot faster and with a larger diversity of people referring to socio-demographical differentiations like sex, age, income, education etc.

5.3.2 Economical statistics
The total sum of the interviews is 213. 72 come from the interviews where the respondents had to indicate an amount of money while the rest, 141 are from the interviews with alternative amounts of willingness to pay. The 72 interviews are also used, although they are not complete, because they give a larger test and a more representative sample of the affected population, concerning the question that is willing to pay more or not for an improvement of the water quality.

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74 See the different amounts in Chapter 6.2 Results of the economic survey.
6 RESULTS

6.1 Analysis results from the water samples

The analysis of the seven water samples taken from La Fuente demonstrated concentrations of nitrate of about 14 mg/l NO$_3^-$ . One exception was concentrations from water taken October 20 that showed concentrations of nitrate of about 3.6 mg/l NO$_3^-$ . Concentrations of nitrite in water taken from La Fuente varied from less than 1.6 µg/l NO$_2^-$ to around 16µg/l NO$_2^-$ . See Table 2 for analysis results.

Table 2. La Fuente$^{75}$

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate mg/l NO$_3^-$</td>
<td>13.09±0.30</td>
<td>14.43±0.31</td>
<td>14.71±0.41</td>
<td>12.45±0.31</td>
<td>3.57±0.19</td>
<td>15.55±0.20</td>
<td>13.36±0.31</td>
</tr>
<tr>
<td>Nitrite µg/l NO$_2^-$</td>
<td>&lt;1.6</td>
<td>9.6±1.1</td>
<td>2.98±0.67</td>
<td>11.5±3.0</td>
<td>&lt;1.6</td>
<td>16.10±0.58</td>
<td>9.4±2.1</td>
</tr>
</tbody>
</table>

The analysis of the seven water samples taken from Los Chorros had concentrations of nitrate of about 3.5 mg/l NO$_3^-$, except water samples from October 20 which had concentrations of 14 mg/l NO$_3^-$ and water samples from October 27 that had a nitrate concentration of less that 0.8 mg/l NO$_3^-$ . Concentrations of nitrite in water samples from Los Chorros varied between less than 1.6 µg/l NO$_2^-$ and 40 µg/l NO$_2^-$ . See Table 3 for the analysis results.

Table 3. Los Chorros$^{76}$

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate mg/l NO$_3^-$</td>
<td>3.23±0.29</td>
<td>4.73±0.28</td>
<td>3.70±0.40</td>
<td>3.34±0.31</td>
<td>14.03±0.20</td>
<td>&lt;0.80</td>
<td>3.53±0.31</td>
</tr>
<tr>
<td>Nitrite µg/l NO$_2^-$</td>
<td>39.85±0.42</td>
<td>3.8±1.2</td>
<td>2.52±0.67</td>
<td>13.0±2.9</td>
<td>&lt;1.6</td>
<td>18.81±0.58</td>
<td>7.7±2.1</td>
</tr>
</tbody>
</table>

Levels of nitrate can be expressed in two ways and it is important that the difference between them is noted. It can either be expressed as N-NO$_3^-$ mg/l or as NO$_3^-$ mg/l. Concentrations of 50 mg/l NO$_3^-$ is equivalent to 11.3 mg/l N-NO$_3^-$.$^{77}$

The water sample taken September 23 from La Fuente had a pH value of 6.4 which is just around the recommended pH value of 6.5. Colour had a concentration of 5 mg/l (U-Pt-Co)
which is lower than the maximal level of 15 mg/l (U-Pt-Co) and equals the recommended concentration of 5 mg/l (U-Pt-Co). Conductivity was about 129 \mu S/cm which is under the recommended value of 400 \mu S/cm. Turbidity had a value of 5.8 UNT. This value can be disregarded as water for the first sample from La Fuente was taken from water flowing on the ground whereas the rest were taken from the tube that transfer the groundwater to the tank where it is chlorinated. Therefore this value had a higher level of dissolved particles than could be expected from water in the tube in La Fuente. The temperature of the water was 20 \degree C. See Table 4.

Water sample from Los Chorros from September 23 had a pH value of 7.6 which is under the maximal pH value 8.5. Colour had a concentration of 5 mg/l (U-Pt-Co) which is lower than the maximal level of 15 mg/l (U-Pt-Co) and equals the recommended concentration of 5 mg/l (U-Pt-Co). Conductivity was about 160 \mu S/cm which is under the recommended value of 400 \mu S/cm. Turbidity had a value of less than 0.4 UNT which is lower than the recommended level of 1. The temperature of the water was 20 \degree C. See Table 4.

Table 4. Physical and chemical characteristics of the samples from sampling made September 23.

<table>
<thead>
<tr>
<th>Sites</th>
<th>La Fuente</th>
<th>Los Chorros</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH at 20ºC</td>
<td>6.35±0.02</td>
<td>7.56±0.02</td>
</tr>
<tr>
<td>Colour mg/l (U-Pt-Co)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Conductivity \mu S/cm</td>
<td>129.0±0.9</td>
<td>159.4±1.1</td>
</tr>
<tr>
<td>Turbidity UNT</td>
<td>5.81±0.13</td>
<td>&lt;0.40</td>
</tr>
<tr>
<td>Temperature</td>
<td>20ºC</td>
<td>20ºC</td>
</tr>
</tbody>
</table>

The water sample taken October 20 from La Fuente had a pH value of 7.4 which is over the recommended pH value of 6.5 but under the maximal value of 8.5. No colour could be detected from the water. Conductivity was about 157 \mu S/cm which is under the recommended value of 400 \mu S/cm. Turbidity where less than 0.4 UNT. The temperature of the water was 20 \degree C. See Table 5.

Water sample from Los Chorros from October 20 had a pH value of 7.4 which is over the recommended pH value of 6.5 but under the maximal pH value 8.5. No colour could be detected from the water. Conductivity was about 127 \mu S/cm which is under the recommended...
value of 400 µS/cm. Turbidity had a value of less than 0.4 UNT which is lower than the recommended level of 1. The temperature of the water was 20 ºC. See Table 5.

Table 5. Physical and chemical characteristics of the samples from sampling made October 2079.

<table>
<thead>
<tr>
<th>Sites</th>
<th>La Fuente</th>
<th>Los Chorros</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH at 20ºC</td>
<td>7.36±0.02</td>
<td>7.36±0.02</td>
</tr>
<tr>
<td>Colour mg/l (U-Pt-Co)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Conductivity µS/cm</td>
<td>157.0±1.1</td>
<td>126.6±0.9</td>
</tr>
<tr>
<td>Turbidity UNT</td>
<td>&lt;0.40</td>
<td>&lt;0.40</td>
</tr>
<tr>
<td>Temperature</td>
<td>20ºC</td>
<td>20ºC</td>
</tr>
</tbody>
</table>

The maximum concentration of nitrates before it is considered as a health hazard in Costa Rica is 50 mg/l NO₃⁻. Water samples from La Fuente had concentrations of nitrates substantially lower than 50 mg/l NO₃⁻. Concentrations of nitrates are except from water samples from October 20 higher in water from La Fuente than in water from Los Chorros. Water taken from La Fuente and Los Chorros had concentrations of nitrites under 100µg/l which is the maximum concentration of nitrite considered a health hazard in Costa Rica.

6.2 Results from the economic survey

Of the 213 respondents 141 got the opportunity to choose among different WTP alternatives. These 141 interviews are used in the statistical estimation. 120 of the respondents (86%) were willing to pay more for an improvement of the water quality and 21 (14%) were not willing to pay more for an environmental change.

The result of the economic survey with the participants from Alajuela gave a mean WTP of 2.4, of a 5 scale interval, which corresponds to a value up to ¢1,400⁷⁰, per month. The calculation can be seen below. The mean level of income, of the entire household per month, is 3.4, of a 6 scale interval, which corresponds to a value up to ¢ 70,000⁷¹.

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⁷⁸ For results from CICA see Appendix 4.
⁷⁹ For results from CICA see Appendix 4.
⁸⁰ ¢1,400 is approximately 22 SEK.
⁸¹ ¢ 70,000 is approximately 1120 SEK
Calculation:
The sum of the 141 respondents WTP: 338
Mean WTP: 338/141 = 2.40
Mean WTP in monetary terms: 1,000 + ((2,000-1,001)*0.4) = 1,400
As the maximum WTP for level 2 equals ₡1,000 this amount is added with 0.4 times the
difference between the maximum and the minimum amount of level 3.

Table 6. The values of WTP used in the interview and in the graphs below.

<table>
<thead>
<tr>
<th>Levels of WTP</th>
<th>Colones, ₡</th>
<th>Kronor, SEK*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Respondent is not willing to pay</td>
<td>Respondent is not willing to pay</td>
</tr>
<tr>
<td>1</td>
<td>0-500</td>
<td>0-8</td>
</tr>
<tr>
<td>2</td>
<td>501-1,000</td>
<td>8-16</td>
</tr>
<tr>
<td>3</td>
<td>1,001-2,000</td>
<td>16-32</td>
</tr>
<tr>
<td>4</td>
<td>2,001-5,000</td>
<td>32-40</td>
</tr>
<tr>
<td>5</td>
<td>5,001-</td>
<td>40-</td>
</tr>
</tbody>
</table>

*Currency counted from ₡500 ≈ $1 ≈ 8SEK. An approximated amount is used as the currency
changed from day to day.

Following subheadings are observations of the correlation between WTP and different
variables.

6.2.1 Willingness to pay among men and women
Of the 141 respondents 73 were men and 68 were women. The mean WTP for men and for
women is equal at 2.4. Figure 8 illustrates the allocation of how much women and men are
willing to pay for a better water quality. The major part of the women, 31%, chose a WTP
amount of ₡1,001-₡2,000. Among the men there were two groups of about the same size: 29%
chose a WTP amount of ₡2,001-₡5,000 and 26% chose a WTP amount of ₡501-₡1,000.
6.2.2 Willingness to pay and different levels of education

3 of the 141 respondents did not reply the question about education. Figure 9 illustrates how the mean WTP changes with different levels of education. The trend is that the mean WTP increases with higher level of education. The largest group, 43%, of the interviewed people, responded that they had completed their second grade, i.e. level 3.
6.2.3 Willingness to pay with different levels of income

134 persons replied to the question about the total income in the household. Figure 10 illustrates how the mean WTP changes with different levels of total income. The trend is that the mean WTP increase with higher income. The largest group, 33%, of the respondents had a total income in the household of €100,000-€250,000.

![WTP and income graph](image)

Figure 10. Mean WTP for different levels of income.

6.2.4 Willingness to pay and different opinions about water quality

Of the 141 respondents 138 answered the question about their opinion of the current water quality. 114 were satisfied with the water quality and 24 were not. Of the satisfied respondents 96 were willing to pay more for an improvement of the water quality. Of the 24 not satisfied respondents 21 were willing to pay more for their water. Figure 11 illustrates the allocation for WTP according to different opinions of the current water quality. It can seem a bit strange that the persons that are satisfied with the water quality are willing to pay more than the respondents that are not satisfied. The explanation can be that the respondents are satisfied with the water quality but if it is a problem with the quality they are willing to do something about it.
6.2.5 Willingness to pay and opinion of water cost

Of the 141 respondents 125 have replied the question about their opinion of their current water cost. 30 respondents stated that they are paying a low fee for the water and the largest part of them responded that they were willing to pay €1,001-€2,000 more for the water. 66 stated that they pay a moderate fee and among their replies no specific amount of WTP can be found as there were three large groups among their replies. 29 stated that they pay a high fee, the largest group among them stated that they were willing to pay €2,001-€5,000. Figure 12 illustrates how WTP is stated according to the respondents’ opinion about their water costs.

Figure 11. Allocation of WTP for different opinions of current water quality

Figure 12. Respondents’ choice of WTP according to the opinion of their current cost for water use.
6.2.6 Willingness to pay and confidence of the distributors

Of the 141 respondents 140 replied the question of confidence in the distributors, the municipalities or AyA, if the respondents believed that the distributors would make the environmental change, and if the water tariff was increased for that purpose or not. 65%, i.e. 91 respondents revealed that they had confidence of the distributors and 49 revealed that they had a lack of confidence. Figure 13 illustrates how the respondents with and without confidence for the distributors are willing to pay more for an improvement of the water quality. The largest part of the respondents with confidence are willing to pay €1,000-€2,000 but almost every respondent is allocated between €500 and €5,000. Among the respondents without confidence for the distributors the largest parts are those who are not willing to pay anything (27%) and those who want to pay €2,000-€5,000 (27%).

![Figure 13. Respondents choice of WTP according to if they have confidence in the distributors or not.](image)

7 DISCUSSIONS

7.1 Water analysis and fertilizer use

The water samples from La Fuente contained concentrations of about 14 mg/l NO₃⁻ while water samples taken in Los Chorros contained concentrations of about 3.5 mg/l NO₃⁻. As the results of the analysis demonstrated higher concentrations of nitrate in water from the coffee plantation at all dates for sampling except for October 20 this can indicate a leaching of nitrate from the coffee plantation. The only explanation found for the difference in concentrations of nitrate is that differences in levels of precipitation affected nitrate leaching.
Concentrations of nitrite varied from less than 1.6µg/l NO₂⁻ up to 16.1µg/l NO₂⁻ in water from La Fuente and from less than 1.6µg/l NO₂⁻ up to 39.9µg/l NO₂⁻ in water from Los Chorros. As nitrite is an unstable chemical form of nitrogen, easily oxidised to nitrate, shifting concentrations were not unexpected analysis results.

Concentrations of nitrate in water taken from the coffee plantation were lower than the limit of 50 mg/l NO₃⁻ set as a guideline for concentration of nitrate that can have an impact on the human health. Concentrations of nitrite in water from the coffee plantation were also lower than the limit of 100 µg/l NO₂⁻ set as a guideline for concentration of nitrite that can have an impact on the human health. These were positive results as the inhabitants in the areas drink the water from the tap.

Even if concentrations of nitrates seem to be quite stable around 14 mg/l NO₃⁻, in water samples from La Pequeña, this might not be the case for water samples taken at different times of the year. Concentrations of nitrates and nitrites leaving the coffee plantation depend on precipitation, temperature and the time when fertilizer is added. Water samples taken during seven weeks are not enough to draw a conclusion regarding nitrogen leaching to the surrounding water. To get a good understanding about nitrate leaching in the area water sampling would be needed to be done at least once a month during one year. The highest concentrations of nitrates are suspected to appear at the beginning of the wet season as the soils might accumulate levels of ammonia during the dry period that can be transformed to nitrate and leave the soil when the heavy rains start. The first fertilization is normally also added in the beginning of the wet season. To see impacts of nitrogen containing fertilizer soil samples could also be investigated.

Recommended amount of nitrogen containing fertilizer added to a coffee plantation is about 300-350 kg/N/year. The amount of fertilizer used in La Pequeña was about 189 kg N/ha/year which is a relatively low amount of used nitrogen. If amounts of fertilizer would be increased this could have immediate impact on the concentration of nitrate in the water taken from La Fuente. It is important that the levels of fertiliser used are well regulated in terms of when and where it is applied.

Values of pH were about neutral at both La Fuente and Los Chorros at the two chosen occasions. Colour had a concentration of 5 mg/l (U-Pt-C) at the first occasion measured at
both at La Fuente and Los Chorros, but were zero at the second occasion measured which means that a higher level iron or organic particles could be entering the water at the first occasion. Conductivity were between 126 µS/cm and 159 µS/cm at both spots and occasions which are lower than recommended and shows that salts where not entering the water in a large extent. Turbidity was less than 0.4 UNT from both spots at the second occasion and at the first occasion at Los Chorros. The turbidity measured from the first occasion at the coffee plantation can be disregarded as the water was taken from surface water.

The spots for the water sampling in this investigation were chosen where drinking water is taken that supports people in the Alajuela province. For a thorough investigation of fertilization impact on the water quality a better understanding of the water movements in the areas is crucial. To be able to convey a study limited in time and monetary terms the amount of water samples taken needed to be narrowed from the primary plan and the spots were chosen according to this.

For a further study of the drinking water in the area it could also be of interest to investigate occurrence of toxic substances in the area. For example at the first water sampling, at La Fuente, endosulphur pesticides were being added to the coffee plantation which could affect the drinking water quality. Unfortunately toxicological water analyses are expensive and for this reason could not be included in the project.

Another problem observed from the coffee plantation is that the land owner at La Pequeña does not follow the recommendations from the Municipality regarding water protection areas. As the land is privately owned the Municipality requires a permit to enter the grounds. The water is taken in an area in the middle of the coffee plantation and the water source does not have the 200 m area of radius surrounding the water where only ecologically grown coffee can be allowed if any at all. The water source is also open to access of human movements as the water source is situated in the coffee plantation. The tubes in the area are also old and in need of repair.

Both areas for water sampling are situated in desolated areas which makes the chances that septic tanks affect the water lower. This is not the case for several areas in the Central Valley where smaller coffee plantations are situated close to inhabited areas. In these areas
surrounding waters might have higher levels of nitrates and nitrites as non-functioning septic tanks can add to the concentrations of nitrates and nitrites.

In Costa Rica a former strategy of how to use a fertilizer in coffee production seems to have been the more the better. Hopefully a better use of fertilizer and a safer drinking water in general can be achieved with a better law for water protection together with a better institutional control of the work with water use and protection. For a further control of concentrations of nitrate and nitrite in drinking water a continuous control of the drinking water quality needs to be done for all of the distributors. Better plans for infrastructure are also crucial to keep water protection areas free from human presence. An improvement of the sanitary water treatment is also needed and a higher percentage of the Costa Rican people need to be connected to public treatment of the waste waters. Fortunately an existing debate of how to work against deterioration of the water resources in Costa Rica is present which can lead to better protection of the water and the human health. One problem is how to finance work needed to be done to change the current distribution of drinking water and treatment of waste waters. In an existing debate on the prices for the use of water it is argued that prices are too low according to the service that is provided. This is something easily said but maybe not the opinion of respondents to the interview with a total income to the household of up to $25,000 which is about 400 SEK a month.

7.2 Discussion about the economic survey
The problem that emerged during the part of the project that included the interview was that the respondents did not seem to pay much or enough attention to the background information. This is according to us the reason for the largest error in the statistical estimation as there is a chance that the respondents did not understand or did not take the problem seriously enough to answer correctly.

Water is difficult to evaluate because of the fact that everybody needs water. No one could manage to live without water and everyone would buy it, maybe not the same amount of it but still, even if the price would rise to the same price level as the water that you can buy in bottles at the market. Therefore, we think that even if the price of water would rise to a higher level than the respondents have answered, he or she would pay to consume water received at their house. Because of the lack of knowledge about the health risks that nitrate and nitrite can
cause and the great importance of having access to water, it is difficult to get a real value. On the other hand a wide knowledge of problems related to water exists, more than anyone can expect of any other natural resource, of course for the reason that everyone uses water every day. It is easier to state a value of a good that is common than a good that is not used as much.

The fact that many of the respondents are poor and have never seen any problems caused by drinking water and are unaware about the consequences that the contamination might cause makes it even more difficult. This problem is not specific for the people in Costa Rica. We think without a doubt that not until a catastrophe is happening in Sweden everyone is going to consume the water without worrying about the consequences.

An interesting discussion we had with the respondents was about their worries that the decision-makers in the municipalities and AyA were going to use this paper to make decisions about future prices of water. Many had a confidence that it was possible to make a difference but not sure that the municipality would do anything about the water situation even if the tariff of the water increased. Therefore they were suspicious about giving us the information about their WTP. Especially they did not want to state a WTP that was unnecessarily high because of the fear that the municipalities or AyA would use their power and increase the tariff of the water higher than necessary and label the rest of the money as a profit.

One weakness of the interview is that it does not fully explain the effects that would appear if more of the respondents and the people in the area would pay more for the drinking water. It is preferred to explain the exact change of quality and restoration. Also the means of payment would be good to include. But we encountered a lot of difficulties in finding out how much money is needed to make a change, which new method would be used to clean the water and how much concentrations of nitrate and nitrite would decrease because of the technique. We were in contact with a lot of people at the municipality, the University of Costa Rica and INTA but they work with other questions than costs of the changes. It would have been interesting to come in touch with people from institutions like healthcare centres, to get a better knowledge of costs of health problems related to polluted water, and with economists, to see how much it would cost to change the water quality to the better, but because of the time limit it was not possible. To make this study better an environmental impact analysis is needed for estimating the costs in physical terms.
An interesting continuation of this project would be to do a cost-benefit analysis and to pay more attention to the costs of making a change and to have more contact and an open discussion with the decision-makers.
REFERENCES

Literature


Umaña, Jorge, *214 familias de Orotina reciben el agua con barro*, La Nación, September 26 2005, San José, Costa Rica

Internet


El Plan Regional Meteropolitano y los Cantones de la GAM, [http://www.ifam.go.cr/PaginaIFAM/docs/Planreg-cantGAM.pdf](http://www.ifam.go.cr/PaginaIFAM/docs/Planreg-cantGAM.pdf), March 1 2006.


Goitre, Swelling of the Thyroid, [http://www.patient.co.uk/showdoc/27000670](http://www.patient.co.uk/showdoc/27000670), March 1 2006.

Nitrate and Nitrite in Drinking-Water, Background document for development of WHO Guidelines for Drinking-Water Quality, WHO 2003

Nutricion Vegetal Mirat Fertilizantes,

Solkaffe – Ett hot mot mångfalden, Svenska Naturskyddsföreningen,

Socialstyrelsens Författningssamling (SOSFS 2003:17),

Sustainability Analisis of the Coffee Industry in Costa Rica,

Travel excellence,

Personal contacts


Oscar Rodriguez Gonzales, Manager of La Pequeña, September 30 2005.

APPENDIX

Appendix 1 – Abstract of the seminar
Appendix 2 – Photos
Appendix 3 – The interview
Appendix 4 – Articles from local and national newspapers
Appendix 5 – Map over the area where La Pequeña is situated
Appendix 1
The seminar was introduced with a presentation from Dr. Jenny Reynolds-Vargas about an investigation that UNA made from the Barba Aquifer. More than half a million persons receive water from the Barba Aquifer. In the area land use is dominated by coffee plantations. For twelve years water samples had been taken at twenty points for analysis of primarily nitrate and nitrite. The investigation demonstrated that coffee plantations together with urbanisation, with non functioning septic tanks probably gave most of the nitrates to the waters. Concentrations of nitrates were not over the recommended level for drinking water but increasing concentrations were noticed. The recommendation is to get a better regulation for the use of soils and water in the area and to find the sources of contamination.

The seminar was continued with a presentation by Darner Mora Alvarado from AyA who claimed that results from the investigation made by UNA were incorrect. He also presented examples from newspaper articles that he claimed showed upon incorrect results. One thing that he doesn’t seem to have understood though was the difference between levels of N-NO₃⁻ or NO₃⁻ and that they have different values for recommended levels because he kept arguing that the levels of N-NO₃⁻ could be as high as 50mg/l which is not the case decided by Ministerio del Ambiente y Energía, MINAE. He also kept pledging that nitrates do not give an increased risk for gastric cancer. But neither is proved today.

Luis Ganes from ESPH talked about the cost for drinking water. He claimed that receiving drinking water at the low prices that Costa Rican citizens does today is practically to do people a favour. He meant that the price for drinking water should include preservation of the areas surrounding the water to prevent contamination instead of spending money on healthcare for treating waterborne diseases. He claims that not doing this would be to choose the more expensive choice. He also stressed the importance of a permanent disinfection of drinking water, which is not the case today, as well as understanding that use of septic tanks are not enough for taking care of waste waters from the households. He claimed that to solve the water question for the San José area could cost about $300 million. He also added that the legislation for protection of drinking water is not enough and that the municipalities are not doing their job by permitting constructions in areas that should be used exclusively as water protection areas.

Isabela Román who have been working with evaluations of environmental questions in Costa Rica claimed that the situation have not changed markedly in several years.
Appendix 2
Doing the interviews in Alajuela center.

Collecting sample bottles at CICA.

Entrance to La Pequeña.

Pesticide applying in La Pequeña.

Man applying pesticides at La Pequeña.

Melvin Alpízar from CICA at the sample site at La Pequeña.
Oscar Rodriguez and Luis Alpizar at La Pequeña.

Where AyA take the water at Los Chorros.

Cleaning of vegetables.

Therese at the water sample site at Los Chorros.

Therese at a tree at Los Chorros.

Coffee after drying.
Appendix 3
Cuestionario

Somos dos estudiantes de Suecia que hacemos un estudio en cooperación con Instituto Nacional de Innovación y Transferencia en Tecnología Agropecuaria, INTA, y Universidad de Uppsala, Suecia. El asunto de este estudio es de medir niveles de nitratos y nitritos en agua sacado en un naciente situado en San Isidro, Alajuela, y al mismo tiempo conocer si hay un interés entre los habitantes de este área de ver un cambio en la calidad y el manejo del mismo agua.

La conversación con Usted es para conocer la voluntad de pago por el agua, tratando calidad y protección de recursos hídricos. Hemos elegido de entrevistar 100 personas que utilizan agua desde nacientes en Alajuela del manejo del Municipalidad de Alajuela. Esperamos de su colaboración respondiendo a las siguientes preguntas. Toda la información en este cuestionario será manejada de manera de confidencial.

1. ¿Recibe el servicio de agua en su casa?
   ( ) Sí
   ( ) No

2. ¿En que región de Alajuela vive Usted?
   ( ) Sabanilla
   ( ) San Isidro
   ( ) Itiquis
   ( ) Otro. Dónde:……………………………………

3. ¿Le provee la Municipalidad el servicio de agua?
   ( ) Sí
   ( ) No

4. ¿Está satisfecho(-a) con el calidad de agua que Usted recibe? En este caso con mala calidad estamos referiendo a agua con olor, color o si ha notado problemas con su salud
   ( ) Sí
   ( ) No. Si la respuesta con Usted eligió es no, por favor describe por que:……………………………………………………

5. ¿La calidad de agua, le da a Usted confianza de consumirla sin tratarla?
   ( ) Sí
   ( ) No

6. ¿Tratando salud humano, conoce Usted cuales problemas nitratos y nitritos en agua pueden causar?
   ( ) Sí. Cuales:……………………………………
   ( ) No
Deforestación y sobre utilización de tierras han deteriorado la calidad de agua en diferentes partes de Costa Rica. Fertilización de cafetales y otros cultivos puede adicionar nitratos y nitritos al agua que puede ser un riesgo para la salud humano. Por esto un problema actual es de cómo resolver esta situación de la mala calidad de agua en los nacientes.

Lo que estamos investigando es en qué medida los Alajuelenses podrían pagar para mejorar la calidad de agua que consumen. Un aumento de las tarifas de agua significa un ingreso a la Municipalidad que puede utilizar para proteger los recursos hídricos y dar un mejoramiento a la calidad de agua.

7. ¿Quién cree Usted que tiene la responsabilidad de proteger las nacientes de agua?
   ( ) Del Gobierno
   ( ) De la Municipalidad, AyA o otro proveedor
   ( ) De todos, incluyendo los habitantes en el área

8. ¿Cuánto paga Usted por el agua que recibe por mes y cuanto consume (m³)?
   ( ) €………………..  ……………………….. m³
   ( ) No sé.

9. ¿Usted piensa que la tarifa que paga por el agua está:
   ( ) Barata
   ( ) Cara
   ( ) Adecuada

10. ¿Tiene Usted confianza en que la Municipalidad de Alajuela, o otro proveedor, podría mejorar la calidad de la misma, aumentarla la tarifa?
    ( ) Sí
    ( ) No

11. a) ¿Estaría Usted disponible de pagar una tarifa más alta para recibir una agua de buena calidad y para proteger dicha calidad en el futuro?
    ( ) Sí.
    ( ) No

   b) ¿En caso afirmativo, cuanto puede Usted pagar más para recibir una agua de buena calidad?
    ( ) De cero a menos que €500
    ( ) De €500 a menos de €1000
    ( ) De €1000 a menos de €2000
    ( ) De €2000 a menos de €5000
    ( ) De €5000 y más
12. ¿Piensa Usted que el problema de calidad o contaminación de agua es un problema actual?
   ( ) Sí
   ( ) No

13. ¿Conoce Usted de información en periódicos, por televisión o radio refiriéndose a la calidad o contaminación de agua?
   ( ) Sí
   ( ) No

Preguntas socio-demográficas. Estas preguntas están incluidas para tener un conocimiento de la persona entrevistado.

14. ¿Sexo del entrevistado?
   ( ) Hombre
   ( ) Mujer

15. ¿Su edad se encuentra entre?
   ( ) 18 a 25 años
   ( ) 26 a 35 años
   ( ) 36 a 45 años
   ( ) 46 a 55 años
   ( ) 56 a 65 años
   ( ) 66 a 100 años

16. ¿Cuántas personas viven en su hogar? ......................

17. ¿Cuántos adultos viven en el hogar incluyéndose usted?.........................

18. ¿Cuál es su último nivel de estudios aprobado?
   ( ) Ninguna
   ( ) Primaria
   ( ) Secundaria
   ( ) Parauniversitaria o comercial
   ( ) Universidad o más
   ( ) Otros

19. ¿Podría indicarnos el ingreso mensual total aproximado de su núcleo familiar?
   ( ) De cero a menos de $ 25,000
   ( ) De $ 25,000 a menos de $ 50,000
   ( ) De $ 50,000 a menos de $ 100,000
   ( ) De $ 100,000 a menos de $ 250,000
   ( ) De $ 250,000 a menos de $ 500,000
   ( ) De $ 500,000 y más

¡MUCHAS GRACIAS POR SU COLABORACION!
Appendix 4
La CNEN pide declarar emergencia por contaminación de agua en Manantial Subterráneo

La CNEN (Consejo Nacional de Energía Nuclear) recomendó al Gobierno declarar emergencia ambiental por la contaminación de combustibles del manantial de agua subterránea que abastece a 320,000 personas en San José y cerca de Bolín, Heredia.

La declaración fue hecha en vista de que el manantial, que abastece a 320,000 personas, está en peligro. Las autoridades hallaron también que el combustible fue drenado a un pozo de 35 metros de profundidad, ubicado junto a una gasolinera en Bolín, Heredia. La contaminación podría afectar el agua potable gracias a su calidad.
Deben pagar por agua embotellada

214 familias de Orotina reciben el agua con barreño

Administradores del acueducto local denunciaron que río está contaminado

Usuarios pagan $1,800 cada mes por el servicio y compran agua embotellada

Jorge Umaña
Corresponsal

OROTINA, ALAJUELA. Para lavar la ropa de su familia, María Eugenia Robles debe recoger agua de lluvia. Más aún, para bañarse debe primero limpiar el lenguado de las becerros que esparce en el redondo donde lo recoge.

Esta situación es la misma que viven 213 familias más en Guayabal, Masatepe y La Cañada, en Orotina de Alajuelense, donde los usuarios reciben el agua sucia.

“Para el consumo nuestro y de los niños tenemos que comprar agua embotellada a pesar de que pagamos $1,800 por mes”, aseguró María Eugenia Robles.

El 23 de abril, los dirigentes de la Asociación de Acueducto Rural Pital-Centeno, administrador del acueducto, solicitaron la intervención del Ministerio del Ambiente y Energía (MINAE).

Según denunciaron, en la finca Rancho Ecológico El Bosque, en Ramadas de Elníguez de San Mateo, un tractor realizó trabajos y tiró la tierra en el canal de la Quebrada Centeno, lo que originó el problema de contaminación.

“La tierra removida fue depositada en una ladera. Al llegar a la quebrada encontramos que caía al canal”, señaló el técnico forestal del MINAE, Stanley Estrada, en una inspección que realizó.

Otras anomalías son la construcción de un sendero en el área de bosque, dentro de la zona de protección de la quebrada.

El principal problema es la caída de tierra en donde está la toma de agua del acueducto, y son los abominos los que están sufriendo las consecuencias”, agregó.

Nega responsabilidad. Edgar Guízar, Fernández, propietario de la finca Rancho Ecológico El Bosque, dijó, vía telefónica desde su oficina en San José, que no son los responsables de lo que sucedió.

“Recuerdo que hubo una quema hace varios meses. Poco después se comprobó que los camiones y trabajadores estaban cerca de una finca que es de la nuestra”, señaló.

Por el contrario, declaró su interés en colaborar por el mismo suministro de agua para las vecinas de esta localidad alajuelense.

Indicó que ellos se encargan de dar mantenimiento y limpieza gratuita al tanque que abastece a Coyol, el cual está en su terreno.

“Notamos que a fines de 1,400 hectáreas y de ellas 700 son de bosque primario. Estamos reforestando algunas partes”, agregó.

Román Campos Castellón, secretario de la asociación que administra el acueducto, explicó que la suciedad dañó 50 bidetrométricos.

“Secolocó una llave en el tanque de almacenamiento y se contaminó un trabajador que no tiene el paso del agua, principalmente cuando llueve”, describió.

Explicó que en un caso como el actual, la cloración no sirve con el agua lleno de lodo y que con toda razón, algunos usuarios se niegan a pagar el servicio, justificando su negativa en que no es de calidad.

El alcalde de San Mateo, Irwen Masis, dijo: “Hace más de 6 meses recibimos una denuncia y estamos en manos del MINAE en Esparza”.
An increase in the cost of water by as much as 8,000% will help Costa Rica ensure the vital resource is contaminant-free and permanently available, under a decree signed last week by Environment and Energy Minister Carlos Manuel Rodríguez.

The decree, which seeks to ensure the protection of natural resources by quantifying their economic worth and turning their conservation into a profitable venture, will make Costa Rica the first country ever to apply such a strategy to water conservation on a national level.

Meanwhile, members of the Legislative Assembly are working on even broader changes to the country’s approach to water, in the form of a new law that would overhaul the outdated water use law now in place and make it possible to pollute.

While an 8,000% rate increase seems large, actual figures amount to an increase from fractions of a cent to larger fractions of a penny for the country’s 5,000 water concession holders, who produce environmental services as soon as possible. On a more permanent basis, it is part of a proposed new water law awaiting legislative approval.

Like the decree, the goal of the proposed law is to increase conservation and protection of the country’s water sources, primarily by improving an outdated and bureaucratic water administration.

The country’s current water law dates back to 1943; more than 100 other laws and decrees have something to do with water; nearly 17 institutions have some legal power in water management (TI, March 19). All of this results in an outdated and unworkable system, according to José Manuel Hernández of the United Nations Development Program (UNDP), which is funding efforts to return governability to Costa Rica’s water management.

“The problems we face are not caused by lack of water, but rather by lack of governability,” he said.

### Decree Draws on New Environmental Strategy

**REWARDING Conservation:** Tapanti National Park, near Oroel in the province of Cartago, east of San José, is one of Costa Rica’s leading sources of clean water.

receive between $5-7 million dollars a year after 2007 for their role in the production of water—effectively doubling the current national park budget.

Parks will also go to indigenous, private and government-sponsored efforts to protect watersheds.

“We want to have producers of water, like we have producers of milk, of cheese, so that water production is economically profitable,” Rodríguez said.
Athough tropical Costa Rica boasts an abundance of water, demands on the resource are also growing. Among these, agriculture, hydroelectric power, human consumption, and tourist-related activities such as golf courses and water-intensive ecology. Contamination by waste and agriculture chemicals is a reality that threatens aquifers and drinking water supplies, according to Maureen Ballesteros, coordinator of the Global, Natura, National, and international. A recent hearing resulted in the issuance of fines for water use exceeding the allowed amount. Rodriguez signed the decree.

However, studies show that water extraction for different uses amounts to only 3.2% of available water, with the vast majority going for electricity production, followed by agriculture.

Rodriguez admitted that during the administration's existing, there has been a decrease in water extraction, but he added that the current situation is better than before. Rodriguez expects the rates and fees to be set for the new rates to be set in the mid-range.

The minister said it will take a “cultural change” for people to understand the economic value of protecting the country's water resources. In the past, he added, the cost to hydroelectric producers was about $3.50 per cubic meter; now, water costs fall in the mid-range.

Rodriguez said: “If you are thinking of investing in the water market, you should think twice.”

A new rate for water in the Electric Institute (IEE) is going to be set at around $3.50 per cubic meter, which is higher than the current rate.

Rodriguez also said he is going to be looking into the issue of water extraction fees, which have been increasing in recent years. He added that the government is going to set new rates for water extraction fees, which will be published in the official government newspaper La Nacion and take effect six months later.

The proposed law aims to update and clean up the existing law. Under the law, the Ministry of Environment and Energy (MINAE) would oversee all water-related issues. The law would create a National Administration of Water Resources, which would be responsible for granting concessions and permission to companies wishing to use water in the country, and it would also be funded in part by the increased water rates.

The new law would also dramatically increase penalties — now as low as $800,000 — for violations of the law. People who contaminate aquifers or rivers would be punished by up to six years in prison. In addition, people who use more water than they are allowed under their concessions would face up to five years in prison.

Six decades ago, when the first law was written, it was impossible to predict today's level of pollution, industrial development, and urbanization. The national government and the Ministry of the Environment are working on a new law to address these issues.
Appendix 5