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ENVIRONMENTAL MANAGEMENT IN GEOTHERMAL DEVELOPMENT: CASE HISTORY FROM COSTA RICA

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ABSTRACT

The great biological diversity of Costa Rica represents one of its largest resources, and it is a focal point of the country's policies of environmental protection. For this reason the country is recognized worldwide as a leader in protecting the environment. This characteristic constitutes an important challenge for developing geothermal energy according to the policies, as a great part of the recognized geothermal resources is associated with areas with different degrees of environmental protection.

This document discusses the different environmental aspects related to geothermal utilization in the geothermal fields in Costa Rica: how the environmental management has been carried out and the results of this management so far. As a conclusion the sustainable development of geothermal projects in harmony with the environment is feasible and it is necessary to ensure the population's well being.

1. INTRODUCTION

The geothermal energy represents an important percentage of the total energy production in the country (15%). As is known, geothermal energy does not present a big pollution problem, but it is necessary to take actions to minimize the risk of pollution and control the environmental impacts. The first geothermal environmental impact assessment (EIA) in Costa Rica was carried out in 1988. It was the first EIA ever done in Costa Rica; but even so this study includes all the environmental aspects considered in the modern methodology for the EIA, even the social aspects.

Since the beginning of geothermal project implementation ICE (Instituto Costarricense de Electricidad) has been working hard to prevent and minimise environmental impacts. During the first stages of the development the use of EIA was the main tool to ensure green and environmentally friendly development and since 2002 environmental impact assessment (EIA) has been used as a new tool to improve the control and monitoring the environmental aspects.

2. ENVIRONMENTAL LEGISLATION IN COSTA RICA.

Costa Rica has been developing important environmental legislation to protect and prevent negative environmental impacts. Article number 50 of the political constitution of Costa Rica states that all citizens have the right to enjoy a healthy and ecologically balanced environment, and for this reason any operation that affects it adversely is encouraged to be denounced and the impacts demanded to be mitigated.

The main regulation is the Environmental Law number 7554 passed in 1995. This law provides the legal support to protect and obtain a clean and ecologically balanced environment and created the "Secretaría Técnica Nacional Ambiental" (SETENA) as the environmental national authority. The law states that:

- The environment is a national heritage for all the inhabitants. This implies the obligation to protect it but also the right to use it to provide well-being.
- The government has to ensure the sustainable use of natural resources.
- The damage to the environment is a social, economic and cultural offence.
- All activities that can damage the environment need an EIA. It means that all construction projects in Costa Rica need a permit from the environmental authority.

Another important issue is that 25% of the country in environmentally protected, and the most important geothermal resources are associated with protected areas. This particular condition makes future geothermal development complex and demands a new strategy to develop geothermal projects in a more environmentally-friendly way.

3. ENVIRONMENTAL MANAGEMENT EXPERIENCE AT GEOTHERMAL PROJECTS

The commercial field operation in Costa Rica started in 1994 with the Miravalles Geothermal Field and in 2005 ICE started with the construction of the Pailas Power Plant, which is expected to be online by 2011.

Environmental management at geothermal project site has been carried out since 1987, before the beginning of commercial utilization of the field in 1994. This management follows the EIA guidelines, but since 2002 it has been improved using the Environmental Management System (EMS) tools. Before 2002 geothermal projects had an environmental monitoring system, but it was mainly focused on the monitoring of different environmental parameters established during the Environmental Impact Assessment, and did not include the management system of the ISO 14001.

In March 2002, the ICE directive council established the environmental policy for the organization, and ten principles to define it. The ICE policy is as follows: *The Instituto Costarricense de Electricidad plans and develops its activities according to the principle of sustainable development; management is carried out in agreement with conservation, protection, recovery and moderate exploitation of the environment.*

3.1 The EMS Implementation Planning

The implementation was planned in different steps as follows:

a. Initial EMS planning: In this step the revision of the resources is prepared. As a result an environmental collaborators' group need to be formed. The members of this group coordinate people in their working areas to help in the identification of environmental aspects, impacts

evaluation, and implementation of the actions detailed in the environmental plan. Also, they form a supporting environmental group with workers specialized in different processes.

b. Initial system evaluation: This step consists of the evaluation of the actual system in order to determine the necessary changes to comply with the ISO 14001 demands. Based on this information the initial EMS planning was established. The most important changes were related to documentation of actions already carried out.

c. Identifying environmental aspects: This step is maybe the most important because it allows the identification of the origin of the environmental problems and takes place when the organization plans the action to control the impacts. It is performed by checking the different processes step by step, identifying the individual potential points of impact. Once the aspects are identified the group evaluates their impacts by using a value scale that contains the different ranges, considering the frequency of the action, the time scale of the potential impact, the extent, the effects on people, the effects on natural flora and fauna, and public relations with communities and environmental or social organizations. Table 1 shows the matrix of the different environmental parameters evaluated.

d. Identifying legal and other requirements: This is not an easy task, because there are many laws and regulations related to environmental protection. In Miravalles most of the legal requirements have been identified and the procedure is under revision.

e. Establishing objectives and targets: When the significant impacts are identified it is necessary to establish objectives and targets. In Miravalles more than ten objectives have been established, related to both negative and positive impacts.

f. Environmental Management Program: A management program focused on obtaining the proposed objectives. Different departments are now working on finding ways to control the impacts.

g. Procedures: At this time most of the procedures are already documented or in the revision stage. This is an advantage because of the existence of a quality system under the standard ISO 9000 that allows the use of this platform to help the EMS procedures and documentation.

h. Environmental education: The relationship with the communities and others affected by environmental issues is maybe the most important factor in environmental management. It is very important to ensure that the communities know exactly what the project entails. What are the negative and positive impacts on natural, economical, and social aspects? What is the organization doing to control these impacts? What are the social and economical benefits of the project? And what is the importance of the natural resource protection?

The main objective of any EMS is to improve the environmental performance of the organizations in protecting the environment, and to improve their public image and reduce costs. With EMS it is possible to systematize and improve the control of impacts in a continuous way. It is necessary because the process, as well as, the organization, the environmental conditions and legal requirements change. And this means that environmental programs and actions taken also need to change continuously.

EIA is a mandatory requirement but EMS is voluntary. Once the organization has implemented an EMS the development of the EIA will be easier because the EMS has systematized the identification of environmental impacts and provided procedures to control and manage the activities that lead to these impacts. The EMS increases the environmental reliability and the public credibility by demonstrating the organizations´ capacity to identify, prevent and control potential impacts. This makes it easier to develop the EIA and also to get various permits

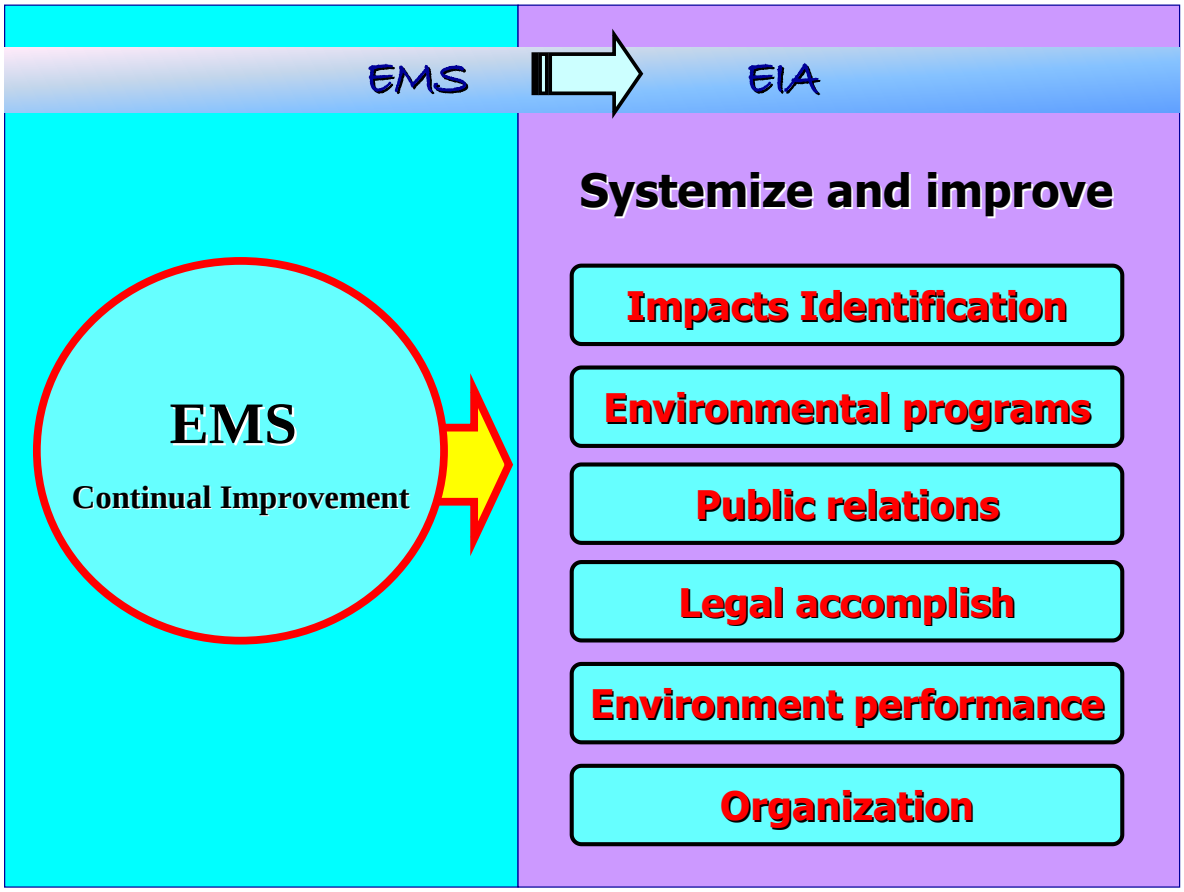

FIGURE 1: Environmental Management System.

3.2 Environmental management results

The EMS is used in geothermal projects in Costa Rica as a tool of continual improvement to administer environmental issues, and can be used successfully to fulfil EIA requirements. The EMS improves the EIA programs because it ensures continual' reviewing of operations, and facilitates the detection of new impacts. The EMS that has been used in Miravalles has 8 environmental procedures to ensure adequate environmental management and additional procedures to control the system.

EMS can improve the implementation of EIA (Figure 2), and also the development of new EIAs. Conversely EIA can provide a baseline for implementing an EMS.

3.2.1 Air quality management

There are different ways by which gas is released into the atmosphere. It can be released from the silencer when a well is out of production. In the centrifugal separators waste water is piped to injection wells and steam to the turbine. In the power plant the gas ejector system extracts the non-condensable gases from the turbine condenser. This gas is cooled and discharged into the atmosphere through the cooling tower.

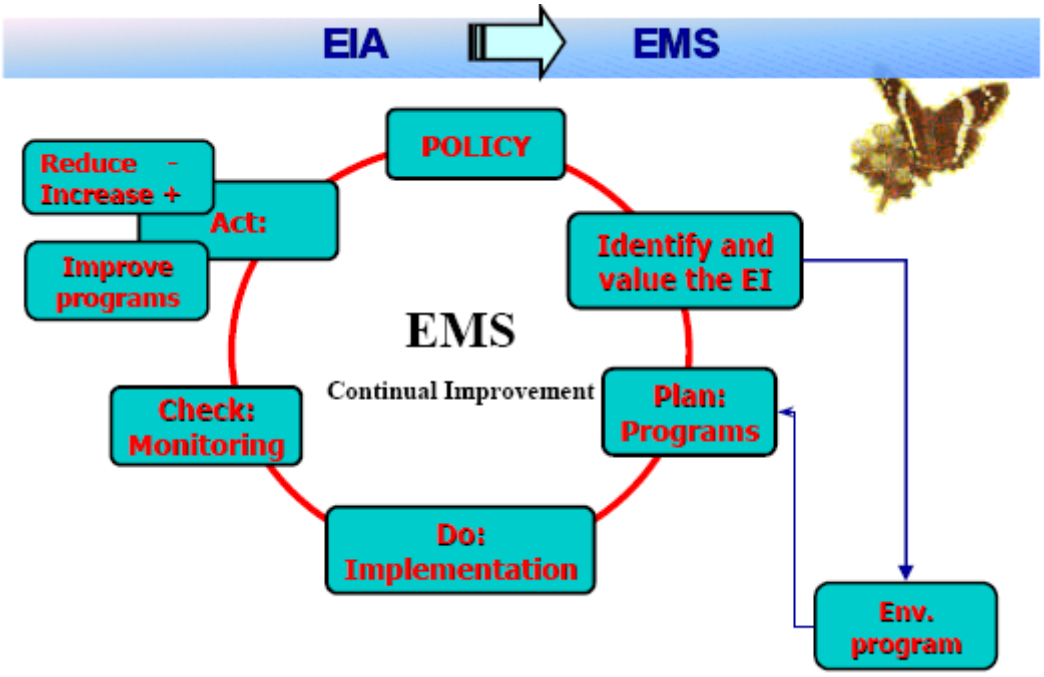

FIGURE 2: EMS and continual improvement

Of these gases, CO_2 (96-97%), and H_2S (less than 1%) are the most important because of possible effects on the environment and human health.

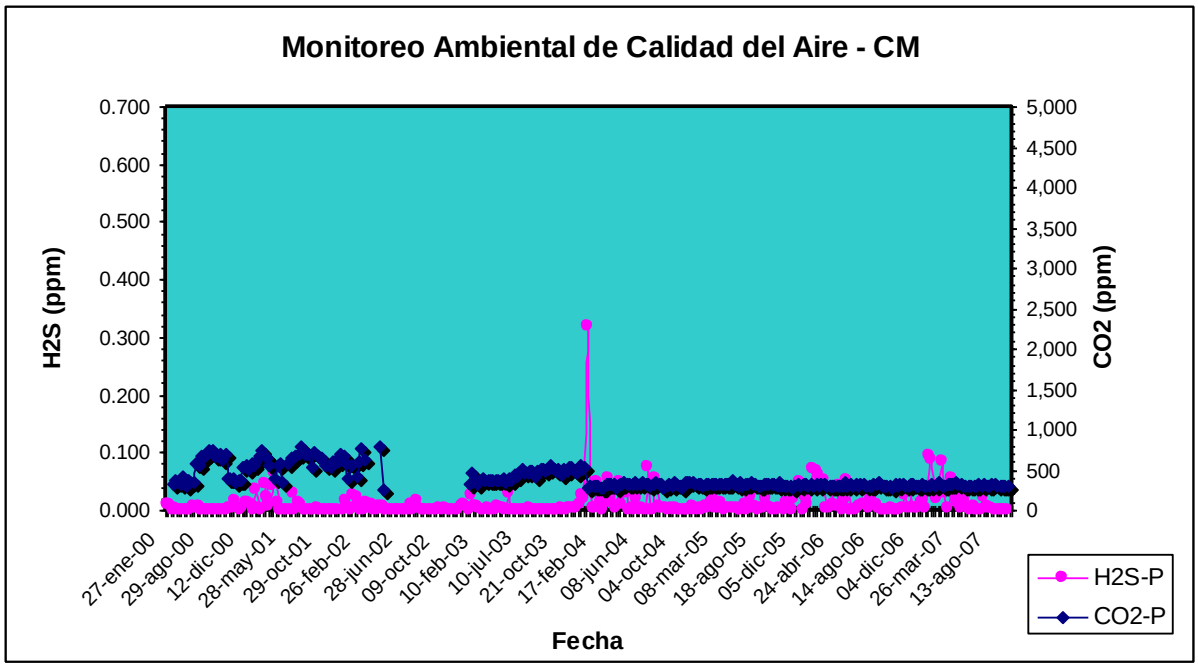

FIGURE 3: Concentration of H_2S at less than 1 km distance from the Power Plant (Miravalles)

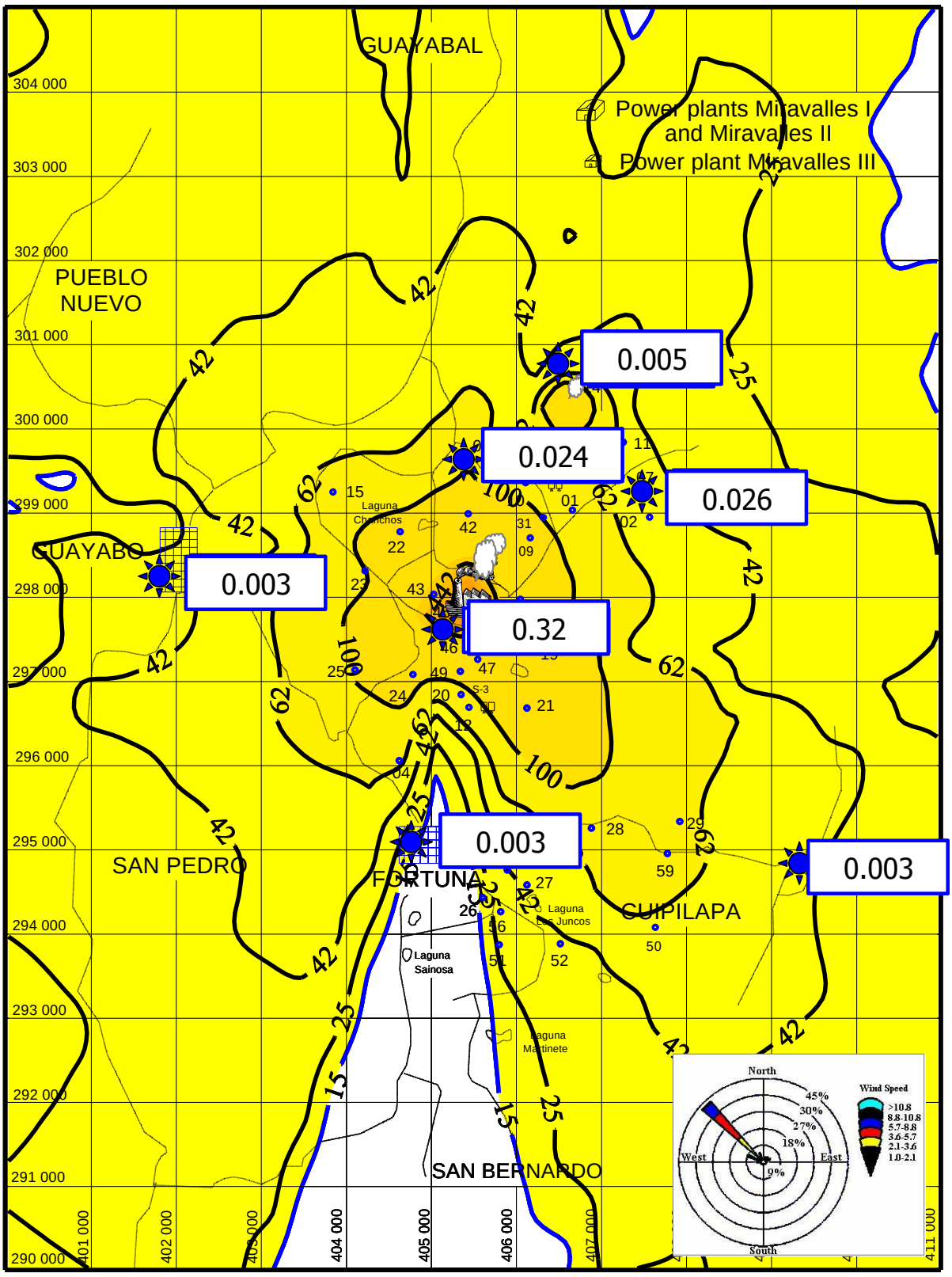

FIGURE 4: Results of a H_2S dispersion model for the Miravalles Geothermal Field.

At 500 μg/m^3 H_2S has a clearly perceptible odour and begins to cause damage to delicate plants. In the range 280,000 to 700,000 μg/m^3 it will cause intoxication and above 840,000 μg/m^3 it can cause death by asphyxia (Reference?).

The geothermal environmental impact assessment (ICE, Miravalles 1996) established the maximum concentration (of what?)of 42 μg/m^3 in populated areas and 938 μg/m^3 at one kilometre distance from the power plants. In the Miravalles geothermal field the hydrogen sulphide emission was modelled in 1988 and 1999. The models estimated H_2S concentrations below 42 μg/m^3 in populated areas and less than 938 μg/m^3 at one kilometre distance from the power plants (Guido, 1999). In order to monitor the H_2S evolution, the Instituto Costarricense de Electricidad (ICE), operates seven H_2S monitoring stations.

Equipment with the capacity to measure concentrations down to 0.003 ppm of H_2S is used. The CO_2 is measured using equipment with a measurement range from 0 ppm to 10,000 ppm. Figures 3 and 4 show the results of the measurements. The results of the monitoring show that the geothermal utilization does not affect the air quality of the project area in any way. In Figure 3 the data at less than 1 km distance from the power plant is presented, and Figure 4 shows the result of the model calculations and the maximum concentration determined during monitoring. The results of the model calculations are conservative because all the measured values are higher than the modelled ones.

3.2.2 Water quality management

In Costa Rica the separated geothermal water is re-injected by deep wells into the reservoir. Therefore it does not represent a pollution problem to the groundwater system. The physical and chemical characteristics of the Miravalles and Las Pailas geothermal fluids do not allow wastewater disposal into soil, springs or rivers in the area.

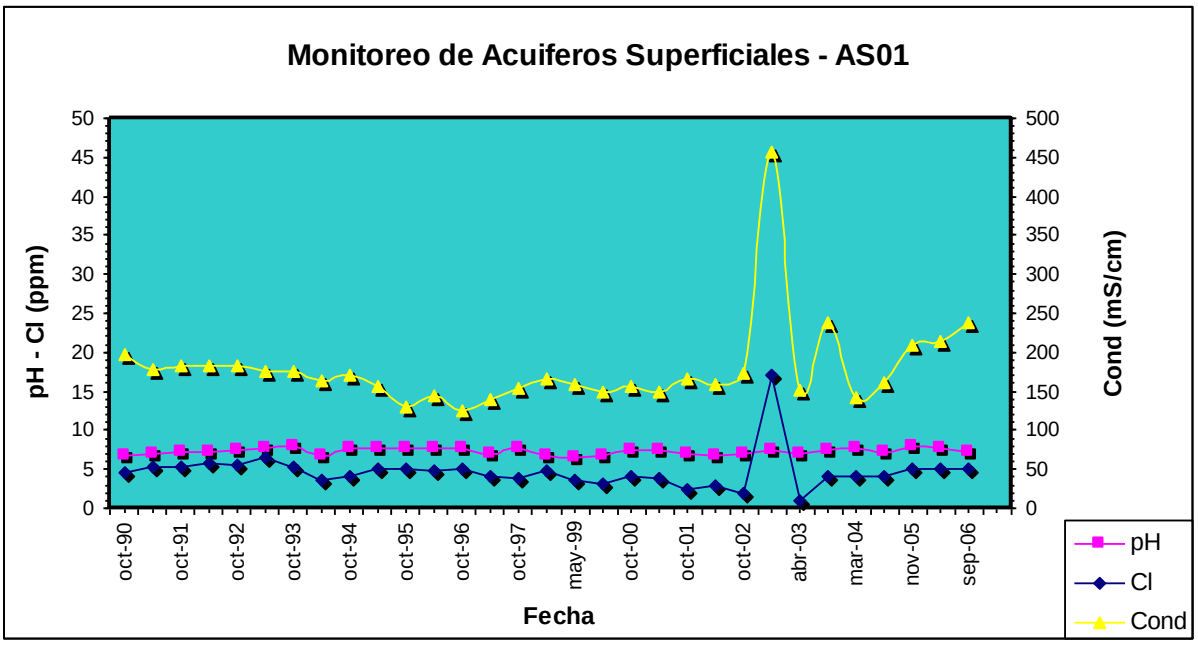

FIGURE 5: Results of water quality monitoring – Station 7

In order to establish a baseline for the water quality monitoring program it is necessary to begin the monitoring before commercial utilization initializes. In Miravalles 26 points in the vicinity of the project area have been established with the objective of detecting possible geothermal water pollution.

At the beginning the monitoring was more detailed (pH, Cl. B, As, Li, Rb, Cs), but after several years it was decided to reduce the number of chemical species monitored. The monitoring now includes Cl, pH and conductivity, because they can be used to indicate the presence of both geothermal and freshwater. Figure 5 shows results of water monitoring at one of the stations in Miravalles.

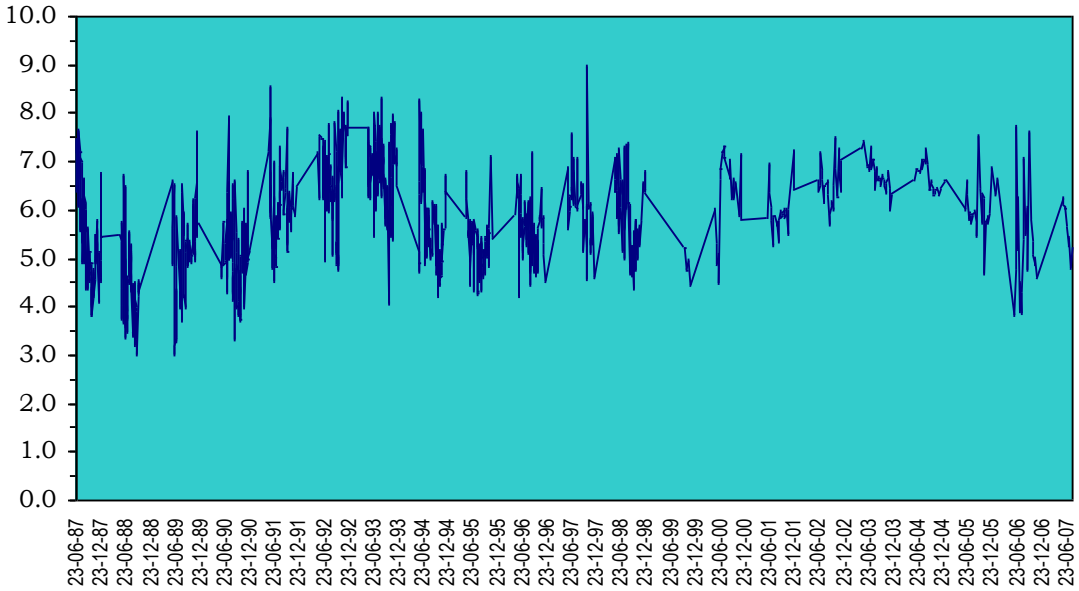

FIGURE 6: Rain water pH – Power Plants Miravalles I – II

In Figure 5 it is clear that one of the results is out of the normal range. This was due to leakage problems in one of the deposition pools. It is an example of the effectiveness of the selected species as monitoring parameters to locate geothermal water pollution problems.

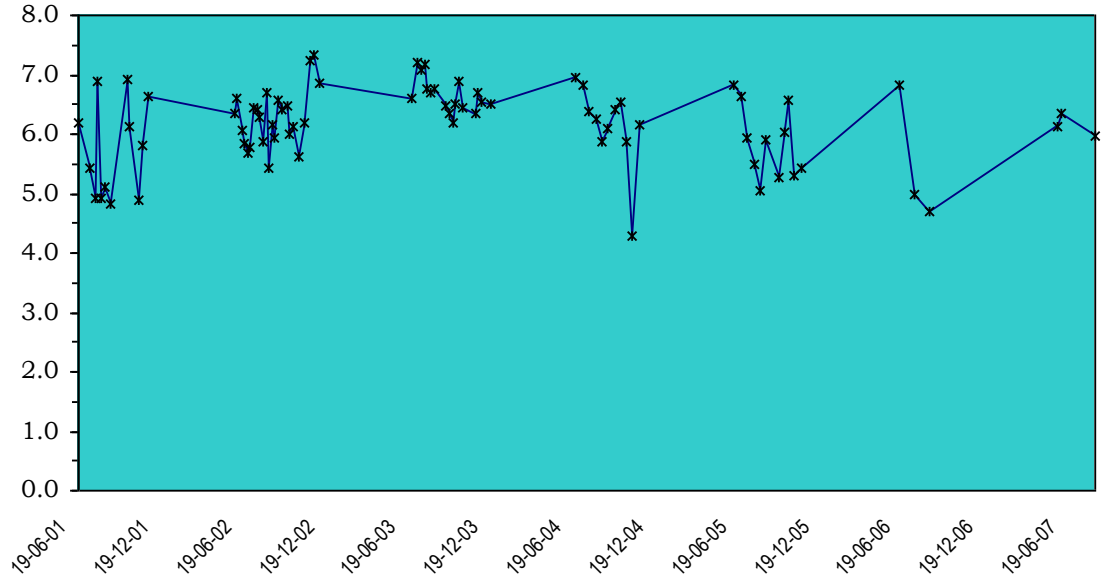

FIGURE 7: Rain water pH – Las Pailas

3.2.3 Changes of pH in rain

Possible changes in pH in rain due to geothermal utilization have been monitored in the geothermal fields. Continuous monitoring was established at different points in the vicinity of the project area. The objective of the monitoring was to determine the pH background value, and use it as a comparison line that allows the identification of any pH changes after the start of the field operation. At this time the monitoring in Miravalles has shown that the field exploitation has not had negative effects on the pH values. Figure 6 shows the results of pH in rain monitoring at the Miravalles Geothermal Field.

Figure 7 shows the results of monitoring in Las Pailas, these results will be used as a baseline to compare the pH evolution after the power plant commissioning.

3.2.4 Effects on forests

In Costa Rica most of the land acquired for geothermal utilization has been reforested by using local flora and promoting natural recovery. When geothermal operations began most of the land was used for grazing. ICE has recovered 800 hectares by planting 362,000 trees in the area. As a natural consequence it is now possible to see animals that were nearly extinct.

Figure 8 shows the difference between ICE´s properties and private-owned properties. The right side of the picture is an ICE property in Miravalles. It is clear the positive impacts of the natural recovery.

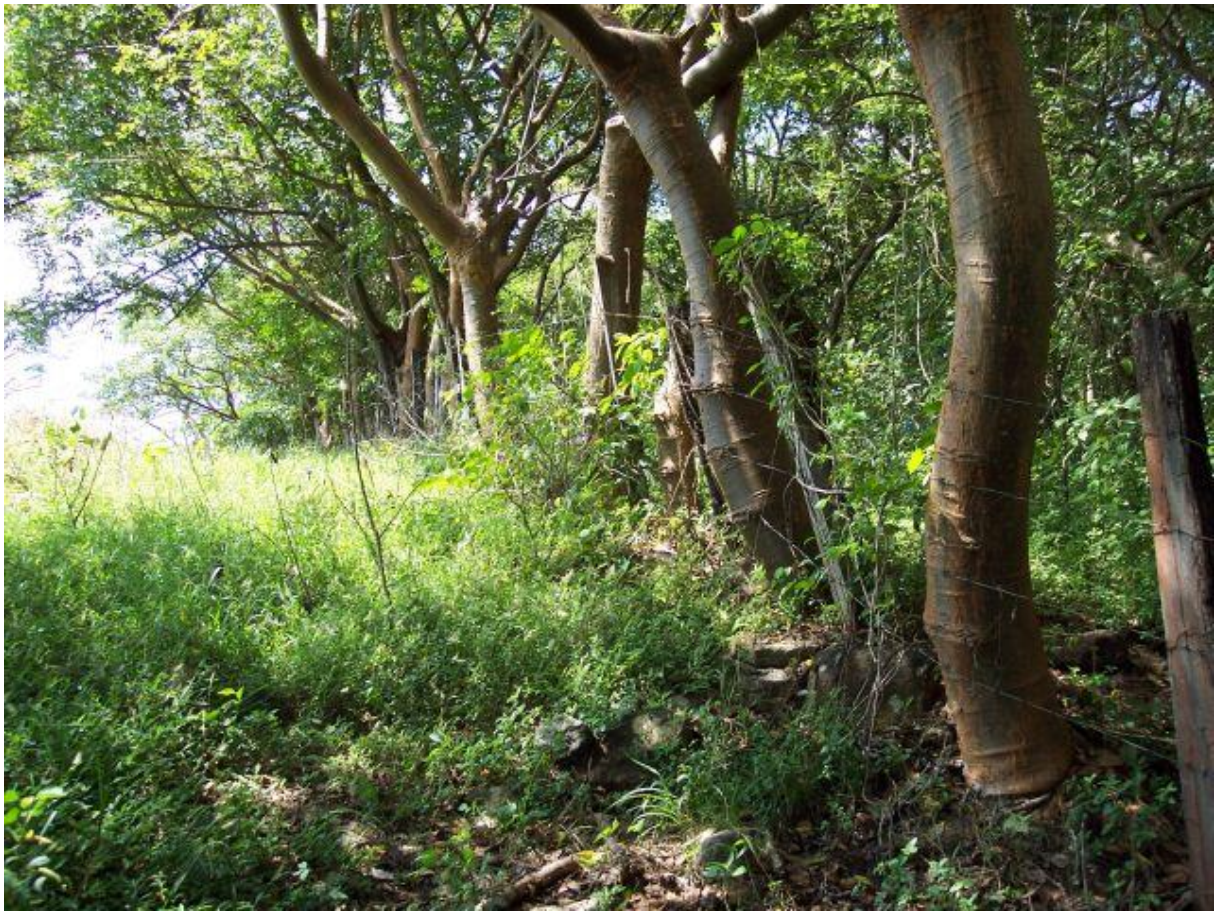

FIGURE 8: Comparison between ICE (right side) and private areas (left side)

3.2.5 Visual impacts

The objective of controlling visual impact is to create harmony between nature, buildings, and pipelines. For that reason ICE has been working with some structures to find the way to improve their visual impact.

Figure 9 shows some of the results of the work for reducing the visual effects of geothermal development. Some of the activities are flora recovery and the use of various shades of green paint.

FIGURE 9: Work site before and after recovery activities.

3.2.6 Social issues

The relationship with communities and other people affected by environmental issues is probably the most important issue in environmental management. One of the most important objectives of public relationship is to inform the communities of the exact nature of the project, including negative and positive impacts on the natural, economical and social aspects. In order to fulfil this objective it is necessary to educate the people. It is important to let them know what constitutes a geothermal project, what needs to be done in order to obtain the resources, how the environment will be impacted, what needs to be done to control the impacts, what are the social and economical benefits of the project and the importance of protecting natural resources.

To manage this situation many strategies have been developed. First it was necessary to identify the strategic groups, for example: social organizations such as development associations, religious groups, students of different levels, hotels and tourist developments, business owners and their workers, NGOs, and many others.

FIGURE 10: Environmental Education

ICE has organized training activities in conjunction with other governmental institutions. One of the most important aspects is related to tourism development. Now the use of natural hot spring water, fumaroles and geothermal utilization are new tourist attractions. About four small and medium tourist projects have been developed using geothermal resources and another small commercial development was born due to the improved life quality raised by the new job opportunities.

FIGURE 11: Geothermal Tourist development

4. CONCLUSIONS

- The implementation of EMS in geothermal development is not an easy task, because the diversity of activities leading to individual impacts is very complex.
- The EMS implementation is an important step on the road to the sustainable development, even if the organization decides not to apply for ISO certification. The results for the environmental parameters show that the geothermal development in Costa Rica is sustainable.
- The natural recovery due to the presence of geothermal developments is extremely important mainly that of the vegetation and the fauna.
- The presence of geothermal development produces new tourist attractions.

5. REFERENCES

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