

Lao
Institute for
Renewable
Energy



Water
Purification
Technologies

2008 Annual Report on Water
Purification Project

Report

10

Leen LABEEUW

Vientiane

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Lao Institute for Renewable Energy

LIRE

REPORT # 10

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Water Purification Project

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About us

LIRE is a non-profit organisation dedicated to the sustainable development of a self sufficient renewable energy sector in the Lao PDR. The institute offers agronomical, technological and socio-economic research services, and works to provide a free public resource of information and advice on the use of renewable energy technologies in Laos. LIRE strives to support the development of the country by exploring commercially viable means to establish renewable energy technologies in rural parts of the country, in areas without connection to the national grid and with little access to technical expertise.

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BORDA

About the project

The aim of this project is to investigate the possibilities for the implementation of a water purification system that is managed locally (by a village entrepreneur) so that villagers can produce their own drinking water. This means providing a service that reliably provides clean drinking water on a permanent basis whilst keeping the costs low so that the villagers can afford the service. The project is operated in cooperation with the *Bremen Overseas Research and Development Association* (BORDA).

Abstract

The accomplishments of 2008 are reviewed, including the various stages of research and development, as well the implementation of the system in the first pilot village of Ban Sor.

1. Background

Clean drinking water is a basic human need, and its availability is a critical factor for health and consequently development. By reducing avoidable water borne diseases such as diarrhoea and cholera and the suffering inherent in these, people are more able to contribute to their community, and further development becomes possible. This important issue has not been adequately addressed in Laos. It is estimated by WHO (2004) that 57% of the Lao population in remote areas is without access, or have inadequate access, to clean drinking water, with diarrhoea the main cause of infant mortality besides malaria.. Water is drunk directly from rivers and streams without being cleaned, or it is collected and boiled, which can be time consuming and damaging to the environment.

The current possibilities for purifying water are: piped systems, wells, and boiling raw water. The former is often not possible in the Lao difficult terrain, especially for more remote systems. Wells have the problem that they are not well maintained so often breakdown (especially hand-dug wells), and the quality of the water is only as good as the container used. Boiling the water requires large amounts of dry firewood and time. Since not all villages have access to larger amounts of wood and a general lack of dry wood exists during the rainy season, villagers often have to drink un-purified water. Even if dry firewood is available, it first has to be cut and transported to the village which means a lot of additional work.

Another issue to consider is that since Laos is only very sparsely populated (ca. 28 persons per km²) most of the villages are off the electrical grid. Connecting the scattered villages to the grid would be extremely costly, so it is not foreseeable that the situation will change for many years. Therefore, it is important that a possible water purifying system is combined with an independent energy source.

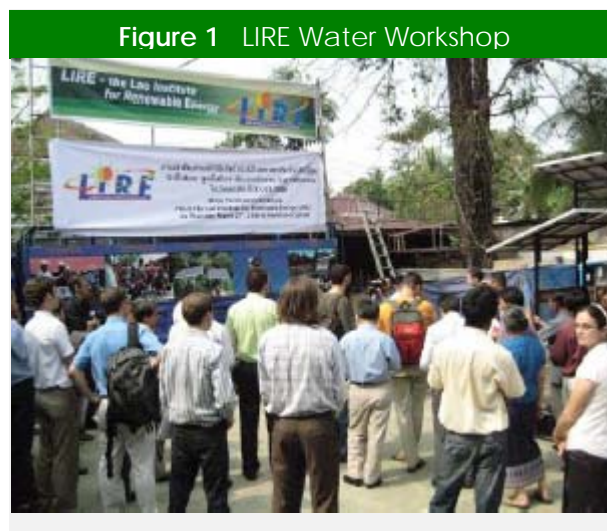
The aim of this project is to find and research a viable solution to provide clean drinking water in rural parts of Laos.

2. Research and Development

The project was started in 2008 with a workshop to introduce LIRE's entrance into the water purification area. This was followed by surveys in various potential pilot villages to assess the need and potential suitability for the water purification. Then a water purification unit, the Water PPS, was field tested in various villages. It was found to be unsuitable however, so the RSD 800 was chosen to be used in the project. Various operating parameters were researched and tested in the workshop, which allowed for operating manuals to be created. With the help *Sunlabob*, a business model was created so that the system could be sustainable. The system was then ready to be installed in a pilot village.

2.1. March Workshop

On 27th March, LIRE hosted a workshop about water purification technologies. This allowed for the exchange of ideas and networking opportunities, as well as heralding LIRE's entry into the field. It was well attended, with representatives from NGO's, commercial companies, government agencies, research institutes and private interested parties present (a total of 23 organizations (not including private or government officials), and 35 people).

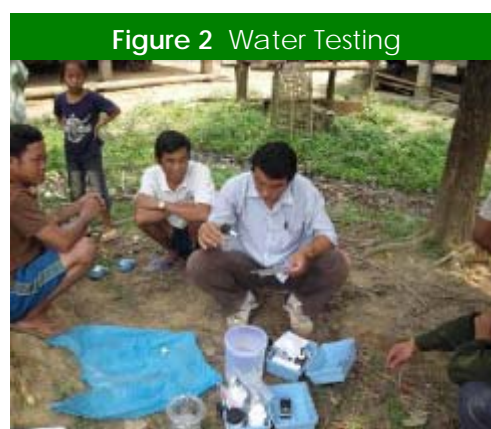


Several ideas were presented, including the localized production of Chlorine from salt and water, the RSD water purification unit and a method (business model) to combine these two features to provide a comprehensive solution, as well as smaller, household clay filters. The event was reported in the *Vientiane Times* and *Lao National Television*, so was successful in introducing the project to the public.

2.2. Surveys of Potential Villages

Baseline studies were conducted in several villages to assess their suitability as a pilot village. These included: Ban Natai, Ban Sor, Ban Thasi, Ban Souanmone, and Ban Phabuek. Unfortunately, travel to Ban Phabuek was hampered by bad weather and road conditions, so had to be cancelled.

Ban Thasi is located 220km from Vientiane, and 20 people were questioned about the status of their health and their willingness to pay. Water tests of the water were also conducted, which showed normal water standards. The studies showed that health is not a major problem for the respondents (70% responded no diarrhoeal associated costs, although 11% of the monthly income was spent on health care), and that willingness to pay for clean water was low (the average was \$1.12 USD per month, or about \$0.04 per day).



The main problem of the village is access is restricted during the rainy season, meaning maintenance and follow up visits (important for the pilot studies) would be restricted.

Ban Souanmone is located in the Vientiane province where the main water source is drilled and hand dug wells. It was tested for water quality, which showed that the water quality was such that it could not be cleaned by the water purification unit (too low pH and too high hardness value).

Ban Natai is in Vientiane province, and had water testing and health assessment surveys performed in it. There are two sources of water: a small river and wells, but all of the respondents of the survey claimed to use wells, which is mostly (66%) perceived as good quality throughout the year. The results of the water testing showed that the river had a high Arsenic content, so would require an additional filter, while the well had too low a pH value (which cannot be fixed by the water purification unit). Most (92%) of the respondents boil their water, although the same amount did not know of nor use soap for washing hands. Despite this, there was a low prevalence of diarrhoea, and low related health costs. Because the villagers use wells (which is generally of higher quality than river water), and because there is only a small problem of diarrhoea and water related diseases, Ban Natai was considered less suitable as a pilot village.

Figure 3 Interviewing



Ban Sor is located 86km from Vientiane, and was first surveyed in May. Most of the villagers obtain their water from a water tank, but this is water taken directly from the river with no purification. Only 33% of the respondents were happy with their water quality all year round, with 38% happy with it for half the year. Most (<80%) said they boil their water and have no/small problems with diarrhoea and the associated costs.

2.3. Water PPS

The first water purification unit to be tested was the Water PPS. This is a system designed by Solar Fabrik in partnership with the Fraunhofer Institute, and combines a water pump and water purification system powered by solar energy. It was field tested in three villages and water sources, namely:

Figure 4 Testing of Water PPS



Ban Koy (hand dug well), Ban Naphor (drilled well), and Ban Sor (river).

All the systems worked under real conditions and provided purified water throughout the 140 testing period. However, a major problem was found as it was shown that the maintenance efforts (although easily done) were too high, especially if the water was particularly turbid (for some cases, it was necessary to change the filter for every 1000L). This significantly reduced the output of the system.

Due to this problem, it was decided not to use the WaterPPS system for the project as it would not be sustainable anymore.

2.4. Unit Testing

Vigorous testing was performed on the RSD water purification unit and the AntennaWATA disinfection system to locally produce chlorine. The RSD unit purifies the water by filtration (to remove chemical contaminants) and UV (and optionally Ozone) disinfection (to remove biological contaminants). It can be customized depending on the quality of the raw water source (i.e. Arsenic filters can be added if necessary). The RSD in the *LIRE* workshop can process up to 2000L per day and has a holding tank (with UV light to disinfect it) for the water. The Antenna WATA produces Chlorine from a saturated salt solution. Both are powered by solar power. Both are robust and simple to use, so should be suitable for use in rural villages.



2.4.1. RSD testing

The RSD unit was tested to determine the ease of use and robustness of the system. This included checking the filter replacement procedure and requirements, the final purity of the water, the mode of operation, etc. It was found to be an easy and robust system.

In addition, the system was tested for use of a sand filter before the RSD unit. It was found that having a sand filter would often cost the same as changing the filters



more regularly, so it was determined to use the sand filter only in cases where the raw water was particularly turbid.

2.4.2. Chlorine Production

Various options for obtaining Chlorine were reviewed, with the main options being locally produced Chlorine vs. imported Chlorine tablets. It was found that although the tablets are more stable, they also require more regulation to import and after one to two years of operation cost more than locally produced Chlorine would. It was therefore decided to use the AntennaWATA system.

Figure 7 Antenna WATA system



Chlorine production was tested with the AntennaWATA, including testing the concentration of the chlorine produced and the sensitivity to various parameters (i.e. run time, lifetime, Chlorine concentration measurement techniques, etc.).

2.4.3. Bottle Disinfection

The bottle disinfection method was rigorously tested. This included testing for Chlorine residue, the optimal method, ease of use, concentration of the Chlorine to be used (and dilution ratios) etc. The amount of bacteria left after the disinfection process was tested until an optimal solution was found that left no Chlorine smell/taste, but decontaminated the bottles.

Figure 8 Bottle cleaning



2.4.4. Manual Production

Based on all these tests, and on the original manuals for the equipment, a comprehensive set of manuals for RSD operation, Chlorine production, Bottle disinfection, and general safety was created. They were designed so as to be

easy to use and follow, ensuring there was no loss of meaning when they were translated into Lao.

3. Installation in Pilot Village

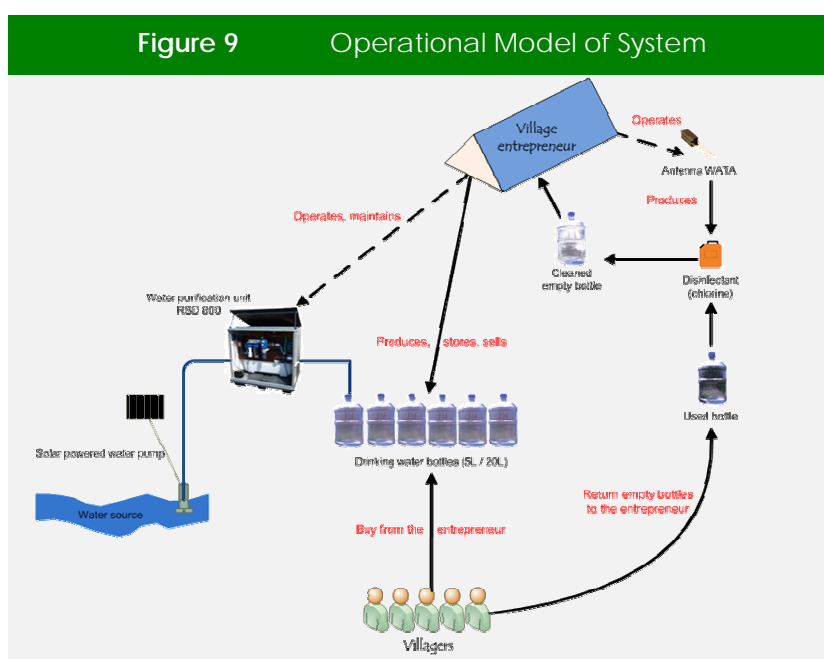
Once the research and development had been completed, the unit was deemed ready for installation in a pilot village. It was done so in the framework of a business model that would ensure its sustainability for many years to come.

3.1. Operational model

The system operates through a combination of public donation and local enterprise, which ensures that it can remain self-sustainable. Similar projects where a public donor has given a water purification system without local entrepreneurship have a tendency to fail after a few years due to lack of maintenance, which is why a vital component for the lasting success of this project is involving a village entrepreneur who sells the water at an affordable price.

The basic model is that a public donor pays the capital costs of the unit, donating the system to the Village. The unit is then managed by the Village Water Committee on behalf of the village, who selects a Village Technician to run the daily operations. The Village Technician sells water in 20L bottles at a price affordable to the 90% villagers (2000 kip per refill), and the money generated pays for his income and for all the maintenance requirements. All replacement parts (and any technical expertise needed) are provided by *Sunlabob*, meaning it is easily and reliably maintained, ensuring a good quality of water. This means that the system will be sustainable in the long-term.

Within the village, the village technician cleans and fills the bottles, which he then sells to the villagers, who return them when done. The model is shown below:



3.2. Selection of Pilot Village

The village on Ban Sor, in Vientiane province, was chosen as the pilot village, as it was shown to have a certain need for the water purification project (there is no purified water source, and most people are only content with their current water quality for half the year or less), as well as being easily accessible from Vientiane which would facilitate follow up visits. Another advantage of this village is that it has a previous good relationship with *Sunlabob*, which makes introduction and implementation of the village easier. After the initial survey, a small follow up survey was performed, although this was disregarded due to the small sample size. The water from the river (the main source) was tested, and was deemed suitable to be purified by the RSD unit.

A field test of the system was performed with water from the river in Ban Sor brought back and passed through the system. It came out clear and purified. This, in addition to the water tests, showed that the unit was ready for implementation in the system.

3.3. Detailed Survey of Pilot Village

Before installation of the system, another complete survey was performed. This included surveys into the willingness to pay (WPS), health impact assessment (HIA), firewood collection, and current water sources and quality. In total 70 people were questioned. At this time (September), the water tank that the villagers had previously used had been shut off (it was a *Sunlabob* installed tank and had been switched off so that it could only be used for the water purification project. Therefore, most of the respondents now used water directly

from the river or rain water, with only 4% using bought bottled water and 22% using wells. 64% claimed the water was only good for half the year. Most of the villagers boil their water and use a toilet with a septic tank, while all claimed to know the benefits of soap. Diarrhoea was a small problem, with 75% claiming to not have a problem, with 50% claiming to not have a problem with back pain (which can sometimes be an indicator of kidney problems). However, 60% of the respondents claimed to spend 50,000 to 200,000 kip on health care expenses per month, which is a sizeable portion of their income (the average income is 256,000 kip per month). 95% of those questioned were willing to pay 2000 kip or more for their daily water needs, which is well within the range of the proposed price of the water bottles. Water was shown to be the highest priority for the village. Since a lot of the villagers boil their water, they were questioned about their firewood collection habits, as this could be impacted by the project. 63% collect firewood daily, while 50% spend over 3 hours to collect it (this can vary depending on the seasons).

These results show that Ban Sor is willing to pay for the system, and the project could directly positively impact the villagers' lives by decreasing the firewood collection times, the diarrhoea and associated health care costs, and providing a source of potable water that is easily accessible.

A comparison of the three different surveys done in Ban Sor was made, which showed the difference in results due to the different seasons and the differences in the questions. It was therefore decided to keep the survey constant so as to ensure that any change of results can only be attributed to change of conditions (i.e. water project) rather than change of questions.

3.4. Implementation in Pilot Village

The system was installed in Ban Sor in late September. This included constructing a house for the system, installing the RSD unit and Antenna WATA, installing all the solar panels, installing a secondary tank and pump (to provide ample pressure to the system), and training the village technicians in the use of the system.

The RSD unit used was slightly different from the one tested in the workshop in that it can process 5000L per day, does not have a holding tank, and uses Ozone in addition to UV for disinfection of the system.



Unfortunately, unforeseen technical difficulties held up the project, as it was discovered that the river water quality varied greatly with the different seasons, and although it had been tested a month before implementation, the RSD was now unable to completely remove the turbidity of the water. This meant additional steps were required, which included a prefilter (sand filter), and additional filters in the unit, with filters of sizes down to $0.5\mu\text{m}$. The problem however, was found to be iron, which cannot be filtered out, so a more radical solution was proposed in the form of a borehole. This was dug to 32m, with PVC lining which has slits for the last 8m to allow water to enter. This system provides natural filtration to remove the river contaminants. After

it was dug, it was found that the borehole had a different iron complex as well, which also caused colouration of the water.

This was a different iron complex though, and after exposure to Oxygen, it coagulates, meaning it is easier to filter out. Meanwhile, the river water quality had cleared up (January), so while some extra equipment was installed to make the borehole water aesthetically pleasing throughout the year, the operational and delivery model of the system was tested with raw water obtained from the river.

Figure 11 Training and installation of system



Figure 12 Installation of system



4. Conclusion

2008 was successful in introducing, researching, and implementing the water purification project. Various aspects of the project were looked into, allowing for a complete model to be formed which will create a sustainable system to be implemented in rural villages. It is a robust system that can be used in areas with no access to electricity or conventional solutions, which will increase the productivity and development of many of these poorer areas.