The Potential Development in System Administration ,Supply Control and Maintenance of Village Ground Water Supply System in Huay Sam Mor Water-shed, Khon Kaen Province

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Abstract

In the Huay Sam Mor Water-shed, Khon Kaen province, there are 15 village ground water supply systems. Recently, only 8 of these keep operating at Sub Somboon Sub-district , Khoke Pho Chai district, Khon Kaen province. The survey of village ground water supply found that the administrative committees and the system intendants never been trained in water supply management, lack of system maintenance, lack of daily system check, neither rust filter tank nor high tower tank were periodically cleaned up, lack of adjusting the water pressure, including chlorination before distribution. The major activities of potential development in this project were based on village water supply administrative committees' need. Being trained and work shop led the village water supply administrative committees to gain knowledge in ground water supply management, as well as capable to practice proper system maintenance. After two months of the potential development, the follow up found that water supply system sites were cleaned up, some sites have water pump checking, adjusting the water pressure regarding with the tower tanks' height, cleaning up rust filter tanks. However, schedules for regular and continuous practices still rely on the village water supply management committee's awareness for good quality of water supply.

Keywords: potential development, village ground water supply system

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Preface

In the Huay Sam Mor Water-shed, Khon Kaen province, there are 15 village ground water supply systems. 13 of them are located in Khoke Pho Chai district, Khon Kaen province, and another two are in Manchakiri district. In Khoke Pho Chai district, there are two village ground water supply systems in Pho Chai Sub-district and 11 in Sub Somboon Sub-district. But the village ground water supply systems lack the actual water. Currently, only eight of them are operating. All of which are in Sub Somboon Sub-district.

Five of the village ground water supply systems in Sub Somboon Sub-district were created as the ground water division, Department of Mineral Resources (Former), Ministry of Industry. Three of them were created as Water Treatment Division, Public Works Department (Former), Ministry of Interior. Later, they were turning over to be under the care of the village water supply management committees. The Sub Somboon Sub-district Administrative Organization has been providing the training on system management.

There have been several problems in producing ground water in eight Sub-district for The Sub Somboon Sub-district Administrative Organization, Khoke Pho Chai District, Khon Kaen Province. The reason seems to be because of the turn over for the village administrative committees, village headman, and maintenance personnel. Especially, most of the maintenance crew has never undergone the training on how to produce the ground water. The maintenance is low, which causes the life span of the ground system is shorten. The maintenance personnel do not clean the filter and the high tower tanks according to cleaning schedule. There is no daily monitoring. The water pressure has never been adjusted. The electricity voltage and chlorine used in the production are high. When the electrical voltage cannot be reduced from pumping up the water, chlorine usage is then reduced. As result, the quality of the ground water, biologically, does not pass the standard criteria as edible ground water (Ministry of Industry, 1999). Moreover, there is a problem with drought during dry season. The amount of ground water that can be pumped is low, which causes low water pressure in the water pipes. The water demand is getting higher, but the water supply is not enough. The ground water has limestone or high hardness, which causes the blockage in the water pipes. Some water supply divisions have to rearrange the water distribution by using schedule time, which causes inconvenience to the people using water.

The village ground water supply system, Sub Somboon Sub-district, Khoke Pho Chai District, Khon Kaen Province, is facing problem of water supply management (Somkid, 2009). In order to improve the village water supply system to produce clean tap water and save for consumption and general usage, the efficient system administration will be required. The researchers are studying the potential development in order to find a way to improve the system administration, production management, and village water supply maintenance system. All of which are the fundamental public utilities that are required for improving people's life style.

Objectives

This research aims to study the village ground water supply systems, which were operating by the village water supply management committees. Also, to study the potential development of system

administration, production management, and ground water maintenance system in Huay Sam Mor water-shed, Khoke Pho Chai District, Khon Kaen Province.

Scope of Research

1. Organize the meeting for potential development of the water supply system in order to discuss the requirements from the village water supply management committees in all eight places. This was to improve the supply and maintenance system according to production schedule. Also, to improve the quality of the water supply up to a certain level in Hual Sam Mor water-shed, Khoke Pho Chai District, Khon Kaen Province.

2. Study the village water supply system focusing on the ground water supply system, which was turned over from Department of Mineral Resources, Ministry of Industry, and the water supply division, Public Works Department, Ministry of Interior; to Sub Somboon Sub-district Administrative Organization, Khoke Pho Chai District, Khon Kaen Province.

3. Data collection was divided into 2 phases: 1) before taking actions and 2) after solving the problems for the water supply production system for 2 months.

4. Use the study of Tap water Quality and Satisfaction of Water Users to village Ground Water Supply in Houy Sam Mor Basin, Khon Kaen Province (Warangkana et al., 2009) If found that any criteria used to determine water quality was under the standard for edible ground water (Ministry of Industry, 1999), the water sample would be collected and tested for that particular criteria again after the development process had undergone for 2 months.

Implementation

1. The pattern of the research was Action Research.

2. The sample people was divided into 3 groups, which are:

2.1. 8 village ground water supply systems, in Huay Sam Mor water-shed, Khoke Pho Chai District, Khon Kaen Province, which was turned over to the village water supply management committees and Sub-district Administrative Organization, were located in 7 villages: Nhong Ya Plong, Sub Dang, Sub Bon, Non Sawang, Sub Somboon, and Sub Charearn, as shown in table 1 and Figure 1.

2.2. The village water supply management committees were the representatives from the village, whom manage the village water supply system. The total number was 28 people consisting of the chairman, secretary, treasurer, and other committees.

2.3. The water supply maintenance personnel were the representatives from the village, whose work involved managing, water supply supply control, checking, and maintaining the water supply system to allow consistency in water supply production.

3. The research tools were divided into 3 parts, which were:

3.1. The water supply surrounding checklist used for inspecting the completeness of the production line structure and the actual procedures of the maintenance personnel.

3.2. Interview dialog for the village water supply management committees consisted of 2 parts. 1) General data of the village water supply management committees, which consisted

of the duration of the assignment, how to achieve the current assignment, other responsibilities in the village, and the training to manage the village water supply system, etc. 2) The state of the operation in human resource, finance, equipment, and management.

3.3. Interview dialog for the village water supply maintenance crew consisted of 3 parts. 1) General data of the production management personnel, which consisted of the duration of the assignment, how to achieve the current assignment, other responsibilities in the village, and the training to manage the village water supply system, etc. 2) The operation of the production system according to the maintenance schedule, which adapted from the operation assessment according to the maintenance schedule of water supply division (2006). 3) Open questions for the problems in maintaining the production system.

4. The research operation

4.1. Stated the purpose of the research (November, 2008) during monthly meeting for the Sub Somboon Sub-district Administrative Organization asking for cooperation in the research from the community leader, the water supply management committees.

4.2. Studied the problems in the operation to produce water supply in the village from the production management team by using checklist and interview about the operation.

4.3. Studied the problems in the management from interviewing about the process including the problems in the operation of the village water supply management committees.

4.4. Used the ground water quality test from the project, Tap water Quality and Satisfaction of Water Users to village Ground Water Supply in Houy Sam Mor Basin , Khon Kaen Province (Warangkana et al., 2009) as the fundamental data for water quality before this research. Used this data and the team meeting to determine the development process to improve water supply production system.

4.5. Facilitated the team meeting in order to find a way to develop the potential for water supply production.

4.6. Proceeded according to the assignment. Analyzed the problems in water supply production process, the missing behavior of the production personnel, and the management of the village water supply management committees, as well as, the problematic water quality. Part of it might be because the production process and periodic maintenance, e.g., the sand filter cleaning process and the cleaning process around the water supply system.

4.7. Informed, followed up, and evaluated the assignment and responsibilities. Evaluated the assignment according to the interview form the production team, the village water supply management committees. Examined the water quality for the problematic parameters and the one that involve in production process. Also, examined the operation obstacles by collecting the data after 2 months of team meetings, which was in February, 2009.

4.8. Collected the water sample for evaluation and comparison with the one before the operation. Considered the parameters were positively different. For example, amount of iron and chloriform bacteria for the village that had contamination during the water analysis before the operation.

5. Analyze the data using descriptive statistics, which was percentage, average, and standard

deviation. For the knowledge in water supply production, used T-Test to analyze the different between the average before and after the training.

Results

1. The village ground water supply production before the potential development operation

1.1. Maintenance Status

The village water supply system operating by the village water supply management committees, under the responsibility of Sub Somboon Sub-district Administrative Organization, Khoke Pho Chai District, was the small angle-corner-shape ground water as 11 of equal-side pentagon. This was according to the former pattern from Department of Mineral Resources (former), Ministry of Industry, and clean water development division, Public Works Department (former), Ministry of Interior. The water supply system pumped the water from the ground well to the production unit. Filled the air until the iron dissolved into rust sediment. Kept it in the high tower tank, which was 12.6 meters in height and 12 Cubic meters capacity. The water was distributed using the pressure from the high tower tang passing the water through the rust and manganese filter tang, but not adding chlorine into the distribution pipes before distributing to the consumers via water gauge.

The status of the village ground water supply system before the operation from 8 places did not have signpost for not allowing pets. Almost all water supply systems could distribute water all day. Except one place that could distribute the water only during morning-evening due to not enough water. Half of the water supply systems (4 places) lacked of cleaning operation around the ground well, water elevated tank, rust filter tank. There was solid wastes and overgrown weed. The ground water pipes were PVC (Polyvinyl Chloride). There were weed and solid wastes around 2 of ground water pipes. All water supply systems had water pumps, which were in good shape and maintenance. The maintenance personnel never changed the control system of the water pumps, never cleaned the high tower tank and rust filter tank, and never added chlorine before distributing water (Refer to table 4 and table 5).

1.2. System Management

System administration of the village water supply was under the responsibility of the headman of each village. This research studied 7 villages and 8 ground water systems. One village had the landscape laid along side the state highway 229, which divided the water distribution and water supply production into 2 systems.

From the interview with35 village water supply management committees in 7 villages, it was revealed that 85.7 are male with average age in 47. 80 $\pm$ 8.62 years old (The eldest was 66 years old, and the youngest was 30 years old.). 57.1% were graduated from primary school. 91.4% were married. 5.7% were widows. 91.4% were farmers and grew sugarcanes. 5.7% were businessman. And, 2.9% were workers. They were the village water supply management committees for average 3.76 $\pm$ 3.66 years (20 years was the longest, and 3 months was the shortest.). They were selected as the village water supply management committees, 54.3% by the consumers, 22.3% by the village leaders. 20.0% were selected because of their titles (headman). 2.9% were selected by Sub-district Administrative Organization. The positions in the village water supply management committees were 20.0% as the president, 8.6% as vice president, 8.6%

as treasurer, 42.8% as committees, and 20.0% as water supply maintenance personnel.

1.3. Maintenance Personnel

There was one group of village water supply management committees per one village. There were 8 water supplies in 7 villages. Hence, there were total of 7 groups of village water supply management committees. The village headman held the position of president of the village water supply management committees.

The organization chart of the village water supply management committees mostly consisted of 5 people (3 villages), 7 people (2 villages), and 3 people (2 villages), respectively. The main positions of the organization chart for the committees were one president, one treasurer, one maintenance, and the rest were committees. All of the village water supply management committees had never undergone the training for managing the village water supply system.

There were 7 maintenance personnel of the study group. The average age was 52.28±10.29 (66 years old was the eldest, and 30 years old was the youngest). Four of them graduated from primary school; two from high school; one diploma. All of them were married. The main occupation was agriculturist, which were 5 of them. The other occupations were one each as worker and businessman. They were working as water supply maintenance for an average of 5.86±6.59 years (20 years was the longest, and 1 year was the shortest.). Becoming the village water supply maintenance 4 of them were selected by consumers, and 2 were selected by village headmen, and the other one by Sub-district Administrative Organization. All of them had never undergone the training for water supply system maintenance.

According to how to choose the village water supply system maintenance personnel and the qualification used as the criteria for choosing the village water supply system maintenance personnel; first, in 5 villages, the person could do accounting. Next, in 4 villages, the person knew about electricity. In 2 villages, there was no such qualification stated. In 4 villages, the village water supply system maintenance personnel did not get any compensation. The rest 3 villages, the village water supply system maintenance personnel got paid 250 baht, 1,000 baht, and 2,000 baht (respectively). The person, who collected the water unit data, was water supply administration, committee, treasurer, equally. Each position for 2 villages, and the headman took 1 village. The person, who collected the money from the water utility bills for 3 villages were the committees; 2 villages were treasurer; 1 village was the system administrative; and 1 village was the headman. The person, who managed the accounting for 4 villages were the treasurer; 2 villages were the headmen; 1 village was the committee.

1.4. Finance

Most of the village, 4 of them, water supply did not have the fund to support the operation. In 3 villages, they received the fund to support the operation for 10,000-12,000 baht from Sub Somboon Sub-district Administrative Organization. The main income for 6 villages was from the water utility bills. In 1 village, their main income was from the water utility bills and the money from Sub Somboon Sub-district Administrative Organization.

In all water supply units, the consumers setup the price by evaluating from the figures in the water gauges. The money collection from water usage was single unit. 4 Villages used 5 Baht

per unit. 2 Villages used 4 Baht per unit. 1 Village used 3 Baht per unit. All water supply units provided the receipt to the consumers when they paid the bills. All water supply units had 30,000-40,000 Baht per year as an income from the water utility bills. They had about 20,000-30,000 baht expenses per year. The expense could be paid by only one person, whom was the committee from 5 villages and the president from 2 villages. The village water supply management committees had allowance for managing; 4 villages had over 1,000 baht and 3 villages had less than 1,000 baht. The income for the water supply units were deposited in the bank for 5 villages. The savings was around 10,000-40,000 baht. The frequency for depositing the money was by convenience in 3 villages, monthly for 2 villages, and the other 2 villages did not have enough income for deposit to the bank.

1.5. Equipment Management

There was an allowance for fixing and maintenance in 4 villages. The other 3 villages did not have allowance. There was backup equipment, which was easily damaged, kept in storage in 5 villages. The other 2 villages did not keep any backup equipment. In 3 places, when the equipment was damaged, the system administrative was ready to fix the problem. In 2 villages, the problem had to be inspected before fixing. In 2 villages, the problem had to be endorsed from the village water supply management committees before proceeding.

1.6. Administration

The water supply units distributed the water to the consumers all day. There was only one village that distributed the water in the morning and in the evening. Most of them were not written procedures (5 villages). 2 Villages had written management procedures. The village water supply management committees had clearly divided the responsibilities. 6 Villages had group meetings. 1 Village did not have any meeting or divided the responsibilities. The frequency of the meeting was about 2-4 times a year. 4 Villages wrote the minutes every time. Most of them, 5 villages, organized the list of the members. 2 Villages did not have the membership list. 5 Villages had savings accounts. 2 Villages did not have savings accounts because they did not deposit the money at the bank. Almost all villages, 6 villages, had the accounting for the water supply units correctly and completely. Only one village did not have accounting for the water supply unit.

Most villages, 4 villages, broadcasted the information about the water supply and monthly income-expenses. 3 Villages did not inform or broadcasted such information. The records and the follow up items from the supply control personnel was inspected in 4 villages by checking the operation data, the amount of water that was produced, expenses and financial records. In 3 villages, they had never inspected or followed up with the operation of supply control personnel.

1.7. Quality of tap water

The data on the quality of tap water before the potential development project came from the study of the project, Tap water Quality and Satisfaction of Water Users to village Ground Water Supply in Houy Sam Mor Basin, Khon Kaen Province (Warangkana et al., 2009). It was found that the sample of tap water from all the distribution sources failed the standard criteria as edible ground water. The most problematic qualification, which all failed, was chemistry and toxic substance. Next was biology, which 2 failed. Only the physical qualification that all passed. The qualifications that did not pass the standard were Cadmium, Iron, Permanent hardness, Total

Dissolved Solids(TDS), Nitrate, and Total Coliforms Bacteria

There were 16 parameters of the water quality standards used in this research, which were color, turbidity, pH, Fe, Mn, Cu, Zn, Cl, No^{3-}, Total Hardness as $CaCO_3$, Permanent hardness, TDS, Cd, Total Bacteria found by Standard Plate Count, Coliform and *E.coli* found by Multiple Tube Technique(MPN). It was found that the tap water sample, collected from the distribution in Ban Sub Somboon # 1, passed the highest of water quality standards for edible ground water, 93.75% of all the water quality standards. Next one was Ban Nonsawang and Ban Sub Somboon #2, which equally passed the water quality standards, 87.50%. The water quality from Ban Nachan Distribution passed the water quality standards the lowest at 75% of all the water quality standards.

2. The Potential Development in System Administration, Supply Control, and Maintenance of Village Ground Water Supply System

The Potential Development in System Administration, Supply Control, and Maintenance of Village Ground Water Supply System was operating by using team approach setting up meetings with personnel, whom involved in supply control. This was to determine the problems and solutions, assign the responsibilities, plan the operation, and coordinate related works. The meeting place and training were the meeting room in Sub Somboon Sub-district Administrative Organization, Khoke Pho Chai District, Khon Kaen Province. The participants and trainees were total of 35 people in December, 2009. Detail below:

1) The result from the workshops revealed that the problem in water supply control was the system administrative and the water supply committees did not know what to do in order to produce good water quality. The water supply management process currently came from whatever had been done in the past. They never had training, and they wanted help in other area related to water supply management. Therefore, the researchers setup the training sessions in maintenance of ground water supply system.

2) Setup the training sessions for the village water supply management committees, supply controllers, and the consumer representatives. The topic was "The village ground management, supply control, and maintenance of village ground water supply system". This was so that they would understand the management process. Explained the conclusion of the data collected from the first phase in system administration, which were accounting, income, expenses, account checking, status of the current water supply system, the process for the supply controllers, the structure of the water supply system that was in good standard.

3) Divided the representatives from the villages into 7 groups. Concluded the problems found in each villages in 3 dimensions from the village water supply management committees, supply controllers, and consumers. Asked for participation as lecturers from Water Management Division 4, Water Resource Management Division 4, Khon Kaen, and also from the researchers, Khon Kaen University. After the meeting, there was workshop in the afternoon. The study was about ground water supply system in Moo 10, Ban Sub Charearn. The structure of the water supply was an ground water supply from Department of Mineral Resources (former), Ministry of Industry.

4) The testing before and after the workshop, "The village ground management, supply control, and maintenance of village ground water supply system", were about general knowledge of water supply production, supply control, and water supply maintenance. Total score was 25 from 25 questions. The village water supply management committees and the consumers, total of 35 people, participated in the test. Before the workshop, the average score was 6.76 ± 3.97. After the workshop, the average score was 16.03 ± 4.49. The score was 9.27 score higher in average. The average score after the workshop was higher than the one before the workshop significantly in terms of statistic (p-value < 0.05) (as shown in Table 2). Before the workshop, the question that the trainees answered correctly the most was no.12, to properly lay out the main water supply distribution pipes, the main pipes should be laid out deep under the ground according to the plan or the predefined detail. Next one was no.2, water canal and vegetable patch were not the ground water source, which could be used to produce tab water. And no.20; sand filter should be cleaned every 2 days or 24 hours of the operation or when found blockage. The questions were answered correctly 74.29, 54.29, and 48.57, respectively. The question that the trainees answered incorrectly the most was no.10, to check the residual chlorine in the village water supply system, the water from the tap furthest from the main water distribution. No.21, checked the residual chlorine when chlorine contact the water for at least 30 minutes and this should be done at the end of the pipe. And no.19, when the water pump was not functioning as normal, the yellow light at the front of the water pump control panel would be on. The questions were answered correctly 5.74, 5.74, and 8.57, respectively. The question that all the trainees answered incorrectly was 1 phase electric power was between 220-240 volts (as shown in table 3).

After the workshop, the question that the trainees all answered correctly was no. 13, PVC pipes used as water supply pipes should be blue. Next one was no. 17, the good quality of the water supply controller was diligent, eager to learn the work, patient, sacrifice, and honest. This question was answered correctly 85.71%. No.2, water canal and vegetable patch were not the ground water source, which could be used to produce tab water. No.24, Water meter showing the figures can be read as 20 cubic meters. And, no.25, water supply controller would be handing over the assignment when deceased, resigned, or when the water supply management committees or Sub-district Administrative Organization. Agreed to dismiss the current personnel. All three of them were equally answered correctly 82.86%. The question that the trainees answered incorrectly the most was no. 21, checked the residual chlorine when chlorine contact the water for at least 30 minutes and this should be done at the end of the pipe. Next one was no. 22, 3 phase electric power were between 340-420 volts. And no.5, the sand filter in the village water supply system should be 0.45-0.55 millimeters. They were answered correctly 22.86, 28.57 and 37.14 respectively (as shown in table 3).

5) The researchers inspected each water supply systems one month after the workshop had ended. They had evaluated the water supply control 2 months after the workshop had ended. It was revealed that the status of eight village ground water supply systems (as shown in table 4 and table 5) the overall water supply area (7 places) was cleaner. All water supply systems had water pumps, water gates, functioning equipment, and schedule maintenance. For the maintenance process, the

maintenance personnel in all area followed the instruction after the workshop. They checked the water pumps, adjusted the raw water pressure according to the height of the high water tank, cleaned the rust filter tank (cleaned the sand filter). The sand filter would be cleaned weekly in 2 places and monthly in 6 places. But the sludge would not be drained out. The high water tank would be cleaned. This was because the work required many people to work on. The villagers spent time by hired to harvest rice and sugarcanes. All the maintenance personnel had to wait for more people to be available, which expected to be in March, 2009. The task that the maintenance personnel could not do were cleaning the ground water well and draining the sludge in the main water distribution pipes. This was because the tasks expensive and lack of equipment. Therefore, they were waiting for the support from the other related divisions. They did not do chlorination before distribution because the consumers and the village water supply management committees did not see the importance and chlorine was smelly.

For the water quality evaluation, the water sample was collected from the distribution units. The water quality, in terms of chemical, and the contamination were tested repeatedly during February, 2009. It was found that the water in Ban Sub Charearn had iron in the amount that passed the standard. For Cadmium, Permanent hardness, Total Dissolved Solids, and Nitrate, in the water from all places failed the standard. The water quality needed to be improved in order to reduce the contamination. For the water quality, in terms of biology, it was found that the water in Ban Sub Dang and Ban Nachan had high bacteria. It did not pass the standard for the edible ground water (Ministry of Industry, 1999).

Conclusion

The Potential Development in System Administration, Supply Control and Maintenance of Village Ground Water Supply System in Huay Sam Mor water-shed, Sub Somboon Sub-district, Khoke Pho Chai District, Khon Kaen Province, seemed to be a medium success. The main activity in developing the potential that the village water supply management committees wanted was the workshop, which would help the village water supply management committees to learn about the system administration, water supply control, and the ability to maintain the system correctly. The determination to get the activities done consistently and continuously was to always get good water quality. This depended on the personal responsibility and the awareness of the village water supply management committees.

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Table 1. Ground water supply system in Huay Sam Mor water-shed, Khoke Pho Chai District, Khon Kaen Province

No	Village	Moo	No. of housing	Population	System infrastructure	Operated since	Coordinates*	Current status
	Sub Somboon Sub-district, Khoke Pho Chai District, Khon Kaen Province							
1	Nachan	1	145	610	Water supply, Public Works Department	2540	48Q0210789 UTM1777752	Opened
2	Nhongyaplogn	2	168	780	Water supply, Public Works Department	2538	48Q0218334 UTM177430	Opened
3	Natubtao	4	158	655	Department of Mineral Resources	-	-	Closed
4	Sub Dang	5	188	482	Water supply, Public Works Department	2538	48Q0214434 UTM1780039	Opened
5	Sampai	6	85	227	Water supply, Public Works Department	-	-	Closed
6	Sampai	6	85	227	Department of Mineral Resources	-	-	Closed
7	Sub Bon	7	110	517	Water supply, Public Works Department	2540	48Q0217202 UTM1770064	Opened
8	Nonsawang	8	57	280	Department of Mineral Resources	2540	48Q0218913 UTM1778784	Opened
9	Sub Somboon	9	114	617	Water supply, Public Works Department	2538	48Q0211314 UTM1778842	Opened
10	Sub Somboon	9	114	617	Water supply, Public Works Department	2540	48Q0211314 UTM1778842	Opened
11	Sub Charearn	10	72	222	Department of Mineral Resources	2542	48Q0212342 UTM1779169	Opened
	Pho Chai Sub-district, Khoke Pho Chai District, Khon Kaen Province							
12	Moonnak	9	145	645	Department of Health	2538	-	Closed
13	Pho Chai	6	204	838	Department of Health	2540	-	Closed

* Coordinates located the geographic location of the ground water system according to global positioning system

Table 2. The average knowledge about water supply production, supply control, and water supply system maintenance; before and after the training (N=35)

Activity	Average	SD	Differences	95% CI		t	df	p-value
			Mean	Lower	Upper			
Before training	6.7576	3.97673	-9.2727	-6.4191	-2.1263	-4.055	34	0.001
After training	16.0303	4.48947						

Table 3. The number of people answered correctly in the list of general knowledge about water supply production, supply control, and water supply system maintenance; before and after the training (N=35)

Detail	Before training		After training	
	No. of people answered correctly	Percentage	No. of people answered correctly	Percentage
General knowledge about water supply production				
1. Sequenced the steps in water supply production process. The correct answer was raw water pump>water supply system>clean water tank>clean water pump> water elevated tank>distribution pipes.	14	40.00	17	48.57
2. Water canal and vegetable patch were not the surface water source, which could be used to produce tab water.	19	54.29	29	82.86
3. Surface water and ground water were the main water source used as raw water for producing tab water.	10	28.57	21	60.00
4. The alum was used in the village water supply system for flocculation and sedimentation	11	31.43	26	74.29
5. The sand filter in the village water supply system should be 0.45-0.55 millimeters.	6	17.14	13	37.14
6. The proper thickness of the sand filter in the village water supply system should be 60 centimeters.	4	11.43	19	54.29

Table 3. The number of people answered correctly in the list of general knowledge about water supply production, supply control, and water supply system maintenance; before and after the training (N=35) (Cont.)

Detail	Before training		After training	
	No. of people answered correctly	Percentage	No. of people answered correctly	Percentage
7. 1 cubic meters of water was equivalent to 1,000 liters.	16	45.71	17	48.57
8. Chlorine was used in the village water supply system to disinfect the bacteria which contaminating the water and in the pipes.	4	11.43	27	77.14
9. 60% of Chlorine meant that there was 60 grams of chlorine and 40 grams of lime in 100 grams of chlorine powder.	4	11.43	17	48.57
10. To check the residual chlorine in the village water supply system, the water from the tap furthest from the main water distribution.	2	5.71	14	40.00
11. There should be 0.2-0.5 milligram per liter of chlorine left in the distribution pipe.	7	20.00	18	51.43
12. To properly lay out the main water supply distribution pipes, the main pipes should be laid out deep under the ground according to the plan or the predefined detail.	26	74.29	28	80.00
General knowledge about water supply production				
13. PVC pipes used as water supply pipes should be blue.	16	45.71	35	100.00
14. The paddle water meters should be installed parallel to the floor / point the arrow to be in the same direction as the flow of the water.	7	20.00	15	42.86
15. There were 2 types of normal water meter, which were one-level and two-level.	8	22.86	15	42.86
17. The good quality of the water supply supply controller was diligent, eager to learn the work, patient, sacrifice, and honest.	11	31.43	30	85.71
18. Before turning on the centrifugal water pump for the first time, it was required to completely fill in the water into the suction pipe in order to get rid of the air left in the suction pipe.	4	11.43	18	51.43

Table 3. The number of people answered correctly in the list of general knowledge about water supply production, supply control, and water supply system maintenance; before and after the training (N=35) (Cont.)

Detail	Before training		After training	
	No. of people answered correctly	Percentage	No. of people answered correctly	Percentage
19. When the water pump was not functioning as normal, the yellow light at the front of the water pump control panel would be on.	3	8.57	14	40.00
20. Sand filter should be cleaned every 2 days or 24 hours of the operation or when found blockage.	17	48.57	20	57.14
21. Checked the residual chlorine when chlorine contact the water for at least 30 minutes and this should be done at the end of the pipe.	2	5.71	8	22.86
22. Three phase electric power were between 340-420 volts.	5	14.29	10	28.57
23. Single phase electric power was between 220-240 volts.	0	0.00	16	45.71
24. Water meter showing the figures can be read as 20 cubic meters	9	25.71	29	82.86
25. Water supply controller would be handing over the assignment when deceased, resigned, or when the water supply management committees or Sub-district Administrative Organization. Agreed to dismiss the current personnel.	13	37.14	29	82.86

Table 4. The status of the ground water supply system in Sub Sombon Sub-district, Khoke Pho Chai District, Khon Kaen Province (N=8)

The status of the water supply system	Number (place) Before the operation	After the operation
1.The surroundings inside the water supply system		
1.1 Production area		
- Clean	0	7
- Reasonably clean	4	0
- Unclean	4	1
1.2 Ground well area		
- Clean	0	7
- Reasonably clean	4	0
- Unclean	4	1
1.3 High tower tank area		
- Clean	0	2
- Reasonably clean	4	6
- Unclean	4	0
1.4 Filter tank area		
- Clean	0	2
- Reasonably clean	4	6
- Unclean	4	0
1.5 Surrounding area		
- Clean	0	3
- Reasonably clean	4	5
- Unclean	4	0
2. No Pets Allowed signpost in the water supply area		
- None	8	8
3. Level of raw water		
1) Raw water pump control system		
- Functioning well with maintenance	0	8
- Functioning, but no maintenance	8	0
2) Raw water pump usage		
- Functioning well with correct maintenance	5	8
- Not functioning well and with incorrect maintenance	3	0
3) Area around raw water source		
- Clean with regular cleaning	6	8
- Have weed and solid wastes around the suction area	2	0
4. Water quality development system		
1) Cleanness of filter tank and surrounding area	0	8
- Filter tank and surrounding area are clean	8	0
- Unclean		
2) Watergate for draining the sludge		
- All functioning well	2	8
- Partially functioning	6	0
3) Sand filter cleaning process (practical)		
- Cleaned correctly (weekly)	0	2
- Cleaned, but not correct process (monthly)	0	6
- Never been cleaned	8	0
4) Reverse cleaning process for sand filter (structure)	8	8
- All functioning well		
5. Water distribution system		
Watergates and equipment in water supply system	6	8
- Functioning with no leakage	2	0
- Little leakage		
6. Water supply quality monitoring		
- No water supply quality monitoring	8	0
- Have water supply quality monitoring	0	8

Table 5. The process in the village water supply management before and after the potential development operation (N = 8)

Activities	The operation frequency (8 places of water supply systems)															
	Before the operation								After the operation***							
	Frequency/times	1	2	3	The operation frequency				1	2	3	The operation frequency				
					Weekly	Monthly	Semiannually	Annually				Weekly	Monthly	Semiannually	Annually	
1. The surrounding maintenance of the water supply location																
- Cleaning and collecting solid wastes	Monthly	3	4	1		3	3	1	6	1	1		6	1		
- mow grass and weed	Monthly	1	6	1		1	5	1	6	1	1		6	1		
2. Ground water well maintenance																
- Get rid of the solid wastes and weed around the ground water well	Monthly	2	2	4		2		2	5	2	1		5	2		
- Clean the ground water well	When smelly	0	0	8					0	0	8					
- Check for leakage in raw water distribution pipes	Monthly	5	2	1		5	1	1	7	1	0		7	1		
3. Water pump maintenance																
- Inspect volt meter and ammeter	Weekly	6	2	0		6	1	1	0	8	0		6	2		
- Inspect the performance of the water pumps	Weekly	3	4	1	3	4			0	8	0		6	2		
- Clean the control panel to prevent animal inhabitants	Monthly	0	2	6			2		8	0	0		8			
- Inspect the performance of the control panel, equipment, wires, and electric poles	Weekly	4	3	1	4	1	2		6	2	0	6	2			
4. Water production and distribution system																
- Cleaning the sand filter	Weekly	0	0	8					2	6	0	2	6			
- Inspect the blockage of overflow pipe and drainage pipes	Semiannual	1	2	5		1	1	1	6	2	0		3	3	2	
- Check the leakage between joints, pipes, and equipment	Monthly	1	1	6		1	1		8	0	0		4	4		
- Fix the leakage on the Watergates and filter tank	Monthly	1	0	7			1		2	0	6			2		
- Check the lightning rod	Annually	2	0	6				2	2	0	6				2	
- Drain the sludge from the water elevated tank	Weekly	0	3	5				3	0	8	0			5	3	
- Clean the water elevated tank	Annually	2	0	6				2	3	5	0			5	3	
- Check for the leakage and clean the main water distribution pipe	Semiannual	0	7	1			6	1	0	8	0			8		
- Inspect Watergates and the main water distribution pipe	Annually	7	0	1				7	8	0	0			8		
- Drain the sludge in the main water distribution pipes	Semiannual	0	0	8					0	0	8					

Note 1 =Action taken according to schedule 2 = Action taken, but not according to schedule 3 = Never taken action ***Inspection data and interview from the water supply maintenance personnel.

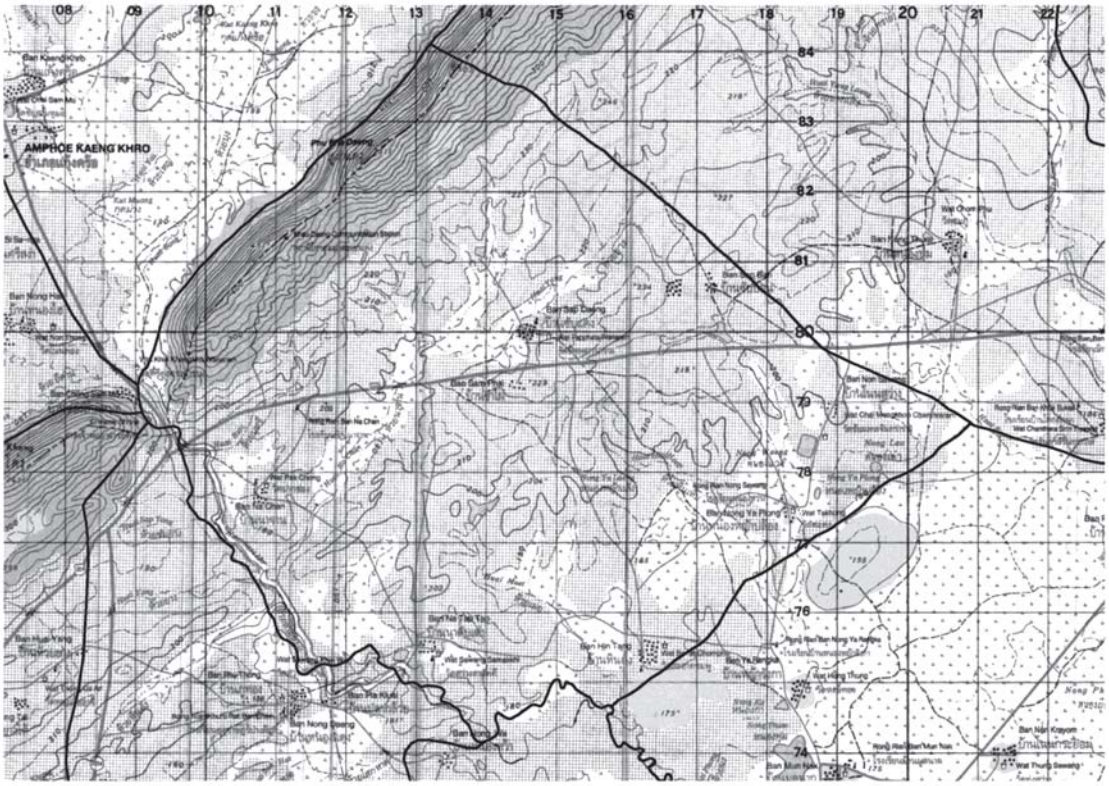

Figure 1. The location of the ground water supply systems in Huay Sam Mor water-shed, Pho Chai District, Khon Kaen Province.