

Characteristics of Water Supply System in K Village: Problems and Villagers' Awareness

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Abstract K village is located in the state of Uttarakhand, India, which has small areas of irrigated farmland. However, the village itself has large areas of irrigated farmland. We interviewed the villagers regarding the water that they utilize for drinking and irrigation on a daily basis, while observing the actual situation on the ground. Through interviews, we noted that less than 50% of the people perceive issues of water shortage during dry season and water pollution. In addition, by direct observation on the field, we traced the pipeline between KT Hamlet of K Village and Sariyatal lake, which lies to the north of this village. We also surveyed the causes of water shortage and water pollution. In this fieldwork, we did not observe any water shortage. However, we did observe several causes of water pollution, including the garbage generated by tourists, detergent used for washing cars, and bloated algae. However, villagers were not aware of these causes. Through this paper, we hope to inform the villagers of probable health issues to animals and human beings, indirectly caused by water pollution. In addition, it is very important to communicate to the villagers that the results of our survey are significantly different from their perception.

Key words Uttarakhand state, drinking water, irrigated water, pollution awareness, water supply

I. Introduction

1. Purpose of the study

Water is an essential factor in our daily life. Spring water in rural areas is mainly utilized for the purposes of drinking and irrigation, in India. It accounts for approximately 88% of safe drinking water in local areas, as well as 45% of the irrigation water.

A large part of the state of Uttarakhand is in mountainous areas, with irrigated farmlands covering only 10% of the total area. The percentage of rural population is approximately 77%, while the remaining 23% reside in urban areas. In this region, about 90% of local people utilize natural spring water for their daily life. However, water supply facilities are not yet advanced in India. Tap water is generally not fit for direct consumption in India. In general, natural water, which includes a small amount of various constituents (viz. dissolved solids, bacteria, heavy metals, etc.) should be properly disinfected before being used for drinking and irrigation, even if there are no major issues with the water quality itself (C.K Jain et al., 2010). Therefore, many people purchase clean water in PET bottles for drinking. This water is available relatively easily, with bottled water being sold throughout India. The villagers in K Village do not buy bottled water, usually using the water overflowing from the mountains for drinking. K Village, which is surrounded by nature-rich mountains in the district of Nainital, in the state of

Uttarakhand, at the foot of the Himalayas, is located in northern India, as shown in Figure 1. Most of the land in this village is occupied by irrigated farmland, with agriculture being the main occupation of the villagers. We focused on the water issue in KT Hamlet of K Village, as it has a widespread water supply system, compared with other areas in Uttarakhand state. However, only approximately 10% of the area in Uttarakhand consists of irrigated farmland in general. In addition, villagers are more likely to use the water for drinking and irrigation, leading to potential health issues.

However, our main concern here was if the quality of the mountain water supplied by pipelines is suitable for drinking. During the course of flowing through the pipeline, there is a possibility that the water may become contaminated or the spring water itself may become polluted. Despite this, the villagers believe that the mountain water is clean, using the water supplied through the pipeline for drinking. Nowadays, the amount of garbage generated is also increasing, with the water becoming contaminated gradually with growth in population and industrialization. If drinking water is contaminated, there is a possibility that serious problems will occur in the future, even if there is no problem currently, with regard to the health of the villagers. Therefore, in order to determine whether the mountain water supplied through the pipeline is really suitable for drinking and agricultural purposes, the water quality in KT Hamlet was monitored. Furthermore, we



Figure 1. Location of K village

Source: made by Raut based on google map, 2017

surveyed the villagers' awareness regarding water usage pertaining to drinking and agricultural purposes, investigating the gap between their perception and facts.

2. Method of the survey

The method of survey used is as follows. First, we gathered information from the local people about the village water supply system. For example, we could obtain information from hotel managers, store clerks, and villagers. Subsequently, based on the information from the villagers, we examined the surrounding environment from the village to the water source by tracing the pipeline. The aim was to investigate damaged pipes and the possibility of contamination of water sources. Further details of this survey are reported in sections II and III.

A survey on the villagers' awareness about the water situation was conducted by having the representatives of each household in the village answer a questionnaire. The population of the village is approximately 400, with 75 households. We considered this to be sufficient as a population parameter for the questionnaire. The contents of the questionnaire and the results are reported in section IV.

II. Water Supply System in the Village

This section explains the village water supply system. Figure 2 shows a map of the entire village, located in the vicinity of Sariyatal lake on the mountain side. The village is surrounded by a rich natural environment, with a booming tourism industry. Dynasty hotel, located in the southern part of the village, accommodates many tourists. First, we asked the manager of the hotel about the outline of the village water supply system.

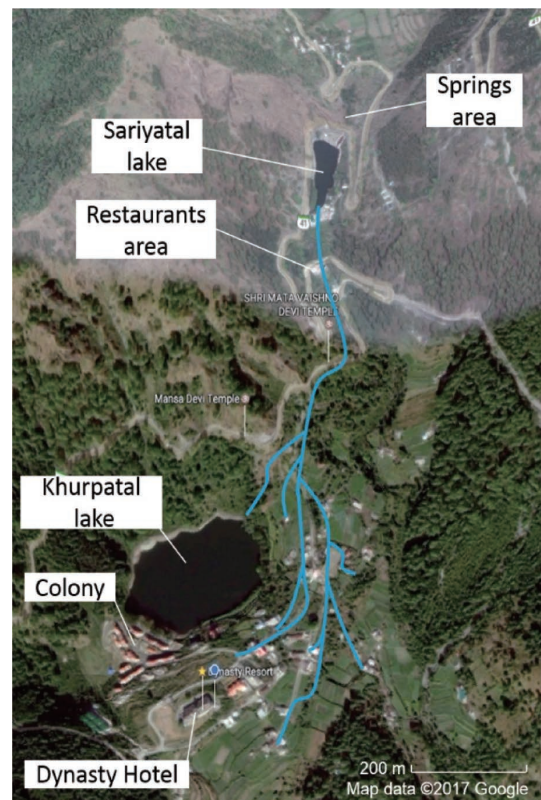


Figure 2. Entire village and the vicinity of Sariyatal lake

Source: made by Ohnishi based on google map, 2017

According to the information obtained from the manager of the hotel, there are two suppliers for the village water, each in a different place. The villagers use the water supplied from the Sariyatal lake through the pipeline, while the Dynasty hotel and colony use the piped water supplied by the Nainital district. KT Hamlet is located in the southwest part of Nainital district. Nainital Municipal Corporation supplies Dynasty hotel and colony with water sourced from the Nainital lake. Figure 3 shows the route

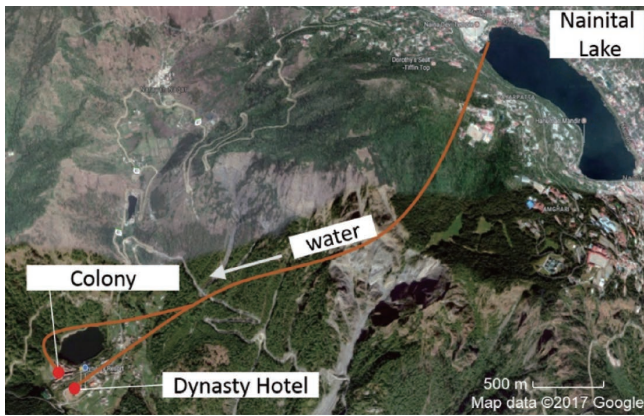


Figure 3. Route of water supply from Nainital lake
Source: made by Ohnishi based on google map, 2017

by which water is supplied from Nainital lake to Dynasty hotel and colony in KT Hamlet. This water is managed by Nainital Municipal Corporation, which guarantees its quality. It is suitable for use by the hotel guests and colony residents. On the other hand, villagers use the water supplied from the Sariyatal lake (Figure 2), located to the north of the village. They use this water for drinking and agricultural purposes. Drinking water is supplied from Sariyatal lake to each house in the village through a pipeline. Agricultural water is supplied from Sariyatal lake to each farm through a canal.

The water used in the village is free of charge, unlike the water used at the hotel. Since the water of Sariyatal lake is used as it is, the quality of water depends on the quality of the water in the lake. If the water in the lake is not clean, the supply of good quality water to the village cannot be guaranteed. Furthermore, during the course of supplying lake water to the village, contaminants can potentially be added, impairing the quality of drinking and agricultural water. We checked the pipeline of the water supply system from the hamlet to the Sariyatal lake, to evaluate the water quality of the lake and the presence of contaminants.

The blue line in Figure 2 is a schematic diagram of the pipeline, recorded by following the pipeline, while Picture 1 shows the pipelines and irrigation canals seen throughout the village. Figure 4 shows the type of pipeline, corresponding to each destination. The thin pipeline indicates drinking water line, while the thick pipeline is used to adjust the amount of water. The thickest pipeline is connected from Sariyatal lake to Khurupatal lake. Moreover, if these pipelines get damaged, it greatly affects the water quality. However, in the places we surveyed, no damage was found, indicating that it is properly managed. In section IV, we discuss the survey of the villagers' awareness, with many villagers suggesting that the pipeline has an influence on landslides. It was confirmed that a landslide



Picture 1. Pipelines and irrigation canals seen throughout the village
Source: Ohnishi, March 2017

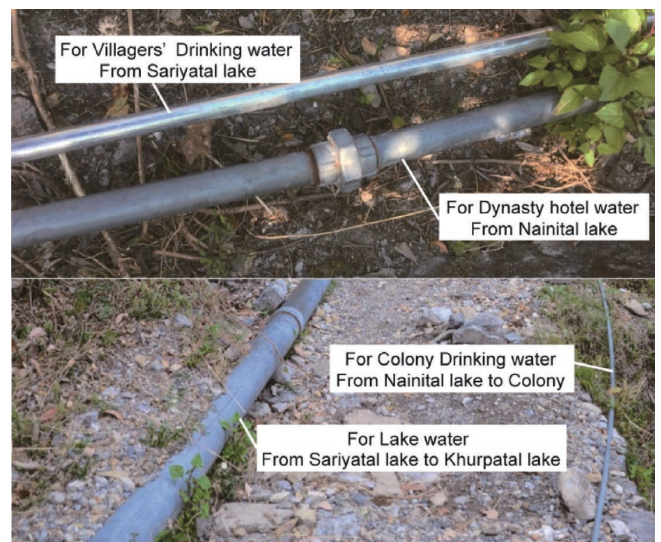


Figure 4. Types of pipeline
Source: made by Ohnishi, March 2017

occurred near the place where the pipeline is installed. However, it may not be connected, since the distance was too large to have an influence on the landslide. They also expressed their opinion on the shortage of water, suggesting that if the pipe is damaged, the supply of water will be cut off, potentially leading to a serious problem. More thorough pipeline management is required.

Subsequently, we explain how the water enters the pipeline. Sariyatal lake is an artificial reservoir that acts like a dam by saving the groundwater that gushes from a place higher than this lake. Picture 2 shows the sluice

gate of the lake. This gate adjusts the amount of water for KT Hamlet. Moreover, the water that passes through this gate is divided into two destinations. One flows into the agricultural canal, continuing to the farms of KT Hamlet. The other destination is a tank in the immediate vicinity



Picture 2. A gate of the pond
Source: Shimasaki, March 2017

of Sariyatal lake. Figure 5 shows a picture of this tank. This tank is connected to a pipe. Once water enters this tank, it flows through the pipe. The presence of another tank for supplying water to the pipes has not been confirmed.

Finally, we investigated the source of the water in Sariyatal lake. The source was found to be groundwater, which gushed from the mountain side, higher than the location of Sariyatal lake. This groundwater flows approximately 30 m below the surface of the earth, with the water quality hardly being affected by external factors such as garbage. Moreover, as observed by some people using this groundwater, its water quality seems to be satisfactory. Picture 3 shows the state of the groundwater and the pump used to draw it. We observed people using water at this place near Sariyatal lake. However, no one directly used the water of Sariyatal lake. This could be because the water quality is poor, even if the water source is groundwater. The reason for this will be described in section III.

III. Water Catchment Area and Pollution

In this section, we describe the condition and pollution of the water catchment area. The drinking water is supplied to each house by pipelines. However, we wanted to evaluate the condition of water. We were unable to do so during its movement from Sariyatal lake to KT Hamlet because this water was enclosed within metal pipes. Therefore, we surveyed the condition of the water catchment area, as we traced these pipes from KT Hamlet to Sariyatal lake. Upon conducting this survey, we observed three causes of water pollution. The map highlighting the positions of the sources of pollution is shown in Figure 6.

First, we discuss the garbage issue around Sariyatal lake. Sariyatal lake is the main source and storage for KT Hamlet. The water in this lake mainly comes from natural springs in the mountain. The water quality is very good. However, we discovered that the water in the lake was

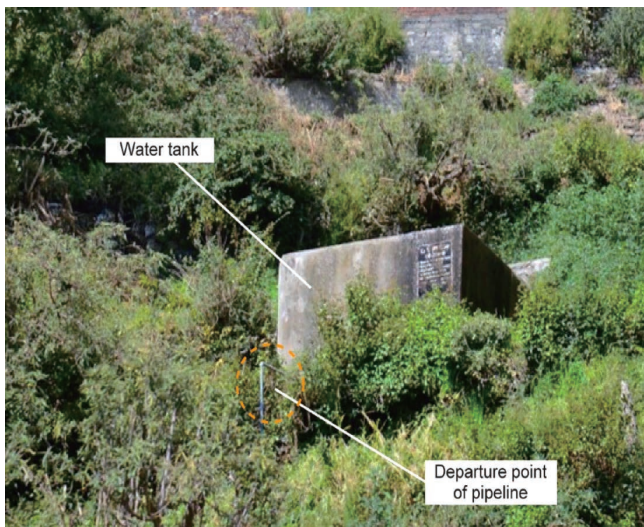


Figure 5. A tank near the pond
Source: made by Ohnishi, March 2017



Picture 3. State of groundwater and a pump
Source: Shimasaki, March 2017



Figure 6. Map of potential pollution positions
Source: made by Ohnishi based on google map, 2017



Picture 4. Car washing
Source: Ohnishi, March 2017



Figure 7. Garbage
Source: made by Shimasaki, March 2017

being polluted by garbage, as we traced the water path following the metal pipes. The condition of garbage around Sariyatal lake is shown in Figure 7. This lake is a famous sightseeing spot in the area, thus attracting many tourists. They often throw garbage on the streets and elsewhere, instead of the trash can. This has led to extensive garbage around the lake, as well as on the way to KT Hamlet. As it is not discarded directly into the irrigation canal, the possibility of the canal water being polluted immediately by the garbage is low so far. However, during heavy rains,

the garbage might flow into the waterways. It could also flow directly into the farm. When the garbage flows into the Sariyatal lake, both, drinking and irrigation water, are polluted by it. Depending on the type of garbage, it could cause the crops to intake toxic chemicals, which could lead to illness in human beings. Therefore, we must consider measures to remove the garbage on the ground, while preventing tourists from littering. If we can maintain the Sariyatal lake in good condition, cleaner drinking and irrigation water can be supplied to the villagers.

Next, we discuss the chemical pollution from car washing. Picture 4 shows car washing around the restaurant near the Sariyatal lake. The restaurant, which is located between KT Hamlet and Sariyatal Lake, is used by travelers and locals as a rest area. Taxi drivers wash their taxis here, almost on a daily basis. Detergents and oils from the car wash flow onto the road. These chemical substances can potentially flow into the waterway eventually. The water supplied to the farm is polluted by the detergent and oil in the waterway. Furthermore, it is absorbed in the soil of the mountain, thus polluting the mountain itself.

Third, we discuss the algae that breed in Sariyatal lake. The small non-harmful algae in Sariyatal lake are shown in Figure 8. The lake was mostly covered with algae, caused by eutrophication due to garbage accumulation. Generally, if the algae are present in a moderate amount, they supply oxygen to water by photosynthesis, creating a hospitable environment for other organisms in the lake. However, overgrown algae consume more oxygen, while producing more carbon dioxide. Excess algae can decrease the ability of the lake to clean itself. The overgrown algae are called Harmful Algal Blooms (*HABs*), which can consume the nutrients in the lake. Subsequently, the algae die, leading to decomposition by the bacteria. This process consumes oxygen, while producing carbon dioxide. The oxygen in the lake decreases rapidly. If the lake is in a



Figure 8. Small algae in Sariyatal lake

Source: made by Shimasaki, March 2017



Figure 9. Big algae in Sariyatal lake

Source: made by Shimasaki, March 2017

hypoxic or anoxic state, the fish will die.

The *HABs* in Sariyatal lake are shown in Figure 9. If people and animals are exposed to the toxins due to *HABs* in the water and food, they may experience symptoms that can range from mild to severe. These symptoms may gradually deteriorate skin, stomach, intestines, and lungs. For example, in 2007 and 2011, approximately 300 people became sick after eating food that was contaminated as a result of *HABs*. These illnesses were reported after people ate fish or shellfish contaminated with *HAB* toxins.¹ In other words, using water for consumption and agricultural purposes from a lake with excessive algae will lead to sickness. If the people in KT Hamlet continue to drink water from Sariyatal Lake without purifying it, the entire village can potentially become ill.

IV. Villagers' Awareness of Water Situation

We surveyed the villagers' awareness of water issues through a questionnaire that aimed to determine the issues regarding water supply recognized by the villagers, while clarifying the issues that need to be resolved.

The content of the questionnaire was as follows. Q1: Are there any problems in the village? Please answer in detail. Q2: Have there been any changes in the drinking water supply recently? Q3: Have there been any changes in the irrigation water supply recently? In Q1, the villagers were asked to list the problems that existed in the village, regardless of the content. With this question, we could determine which problems the villagers felt are the most important, thus judging the degree of the villagers' awareness of water issues. Q2 and Q3 enquire about recent changes in the supply of drinking and agricultural water, respectively. If the answer to the questions was "Yes," the respondents were asked to explain in detail, regardless of whether the details were positive or negative. With these questions, we could get a preliminary idea of the current situation of the water supply system. According to a household survey carried out separately from the water awareness survey, the population of the hamlet was approximately 400, with 75 households. We provided a questionnaire to representatives of the 75 households, thereby receiving responses. The answers to each question are summarized in the tables. As far as possible, the answers have been described as received, with duplicated details being omitted. Table 1 lists the responses obtained for Q1, while Table 2 lists the responses obtained when the answers to Q2 or Q3 were "YES." In addition, Figure 10 shows graphs showing the proportion of responses on water issues to the total answers to Q1. Figure 11 shows graphs indicating the proportion of "Yes" and "No" answers to the total answers to Q2 and Q3.

In response to Q1, 15% expressed concern regarding the water problem, while 49% expressed concern regarding other problems, such as 'tourists', 'transportation', 'schools', 'employment', and 'hospitals'. Others either did not respond or did not perceive any problems. In other words, approximately 15% of villagers were interested in water issues, in particular. The cause of concern was water

Table 1. Answers of Q1

Answer of Q1	Regarding water problem	1	Water supply facility is not good, Lack of transportation
		2	Outsiders are capturing water resources; Garbage; feeling of insecurity because of outsiders.
		3	Water shortage in summer
		4	Disturbance by tourist and tourism activity.
		5	Less water, with increasing tourist, pollution, and throw garbage
		6	Lack of water for agriculture and drinking
		7	Problem of drinking water because of mis management of water, because people some time use drinking water for irrigation
		8	Lack of irrigation water in summer season.
		9	Water shortage in summer
		10	Water problem due to population increasing
		11	Irrigation canals damaged in some parts
		12	Drinking water shortage
	Regarding tourists	13	Tourists misbehave. They enter in the agricultural land without permission; Transportation Problem; Lack of available employment for women
		14	The dynasty hotel doesn't provide any guide to the tourists. Because of this, tourists interrupt their farmlands.
		15	Tourists create so many problems.
		16	Outside people coming as tourists interfere with local culture and society
		17	Disturbance by tourists at late night
		18	Sound pollution form hotel
		19	Many people are coming and throw garbage.
	Regarding transportation	20	Road/Transportation problems
		21	Lack of transportation.
		22	Road condition not so good
		23	Not properly constructed road
	Regarding school	24	School is not good.
		25	Boys college, not sufficient mean of transport to Nainital
		26	English medium school is not available
	Regarding employment	27	Lack of employment for those who are skilled but unskilled labor get enough
		28	Lack of employment.
	Regarding hospital	29	No hospital; no secondary school for boys
		30	Lack of medical facilities
	Regarding other topic	31	New generation does not care about elderly people and traditional knowledge
		32	Because of forest fire, grass is less, and some time forest department not work properly.
		33	Wild animal attacking the crops.

Source: GHS data collected by the Taoyaka onsite training in March 2017

pollution due to garbage, increase in population and tourists, water shortage due to a decrease in rainfall, waterway damage, etc. In the survey described in sections II and III, we could not confirm waterway damage and water shortage. However, we determined the cause of potential water pollution. Garbage found near the source of water is believed to be due to the increased population and tourists. Despite this, very few villagers mentioned it as a potential cause for pollution in the survey.

With regard to Q2 and Q3, “Yes” answers were less than

“No,” accounting for less than half of the total. Moreover, among the “Yes” answers, negative changes accounted for most of the responses. The answers related to positive changes were only those mentioned in No. 13 and No. 19 of Table 2. The content of these answers was nearly the same as those in response to the supply of water, obtained for Q1. From the answers to Q1 and Q2, it can be seen that the recent village water supply system is worsening due to the deterioration of water quality, decrease of rainfall, and pipe deterioration.

Table 2. Answers of Q2 and Q3

Answer detail of Q2	Regarding pollution of water	1	Water became more polluted
		2	Polluted water because of tourists
		3	Horse manure from sariyatal lake, sometimes contaminates water sariyatal lake is where their drinking water comes from)
		4	Increased in population
		5	Polluted due to mis management
		6	Because of increase shop and population. Water is polluted
	Regarding water shortage	7	Long periods without water; water resources distributed inequality; as a woman it is harder to access water
		8	Summertime's springs dry up, not enough drinking water
		9	Less rainfall, population increase
		10	Less water due to mis management
	Regarding damage of waterway	11	Pipeline damage (land slide)
Answer detail of Q3	Regarding pollution of water	1	Quantity is low
		2	They use new technology like drip irrigation and flood (canal irrigation)
	Regarding water shortage	3	Water is declining compare with past. Dry season is not enough rain fall.
		4	Canal
		5	Summer (May, June) it dried, decreasing compare with 10–20 years ago
		6	Water level has decreased
		7	Springs have less water
		8	They have started irrigating through canal
		9	Less rainfall and reduce the sources of lake
		10	Less rainfall. Due to the use of cement in construction of lake surrounding water source are less
	Regarding damage of waterway	11	Some irrigation canals are damaged

Source: GHS data collected by the Taoyaka onsite training in March 2017

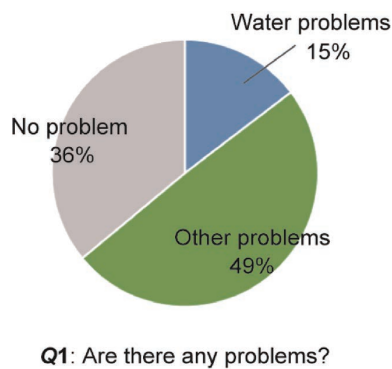


Figure 10. Percentage of answers related to water for all answers of Q1

Source: GHS data collected by the Taoyaka onsite training in March 2017

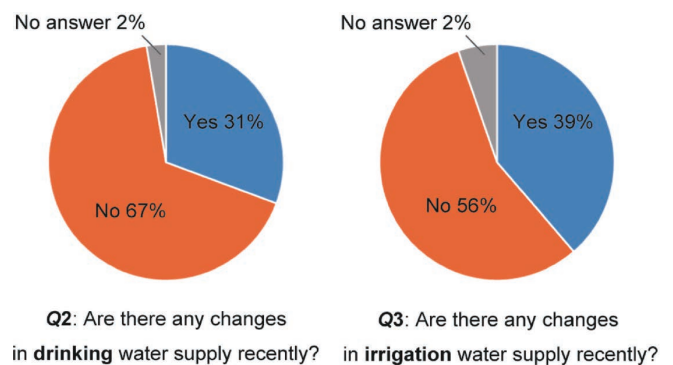


Figure 11. Percentage of 'Yes' and 'No' for all answers of Q2 and Q3

Source: GHS data collected by the Taoyaka onsite training in March 2017

Looking at the results of the entire questionnaire, some villagers are conscious of water problems, although they were a minority. Based on our findings, we are aware of the high possibility that drinking water and agricultural water supplied to the village by the pipeline are contaminated. By informing the villagers of this fact, the villagers'

awareness of water supply issues should be increased. We believe that this would lead to the improvement of the village water supply system.

Based on the answers to the questionnaire, a significant number of people expressed that water shortage, caused by a decrease in rainfall and population increase, is a

problem. In this study, we could not confirm this fact. Therefore, further investigation is necessary.

V. Conclusion

In this study, we conducted field work and interviews, to recognize the actual situation and the potential causes of pollution with regard to the water used in the village, as well as the awareness of the villagers. Initially, we found that there were four types of metal pipelines in KT Hamlet. However, we decided to trace the water path, by following the pipelines to the Sariyatal lake, which is the water catchment for KT Hamlet, since we were unable to see inside the pipelines. KT Hamlet and Sariyatal lake are famous sightseeing spots in the Nainital district of Uttarakhand state of India. Therefore, many tourists come to this area. The tourism is developing nowadays, which can lead to water pollution, caused mainly by garbage.

Through our survey, we determined that the villagers' awareness is slightly different from the actual situation. In other words, villagers sometimes misunderstand the actual problem. Some of villagers were aware of the water pollution due to garbage. However, they were not aware of the fact that they had also used water polluted by garbage, detergent, oil, and algae. Generally, villagers believed the quality of water was not a problem. It is not possible to judge the water quality only by seeing the water. It can be dangerous to drink it and utilize it for irrigation. By being unaware of the presence of some toxic components in water, it is difficult to remain healthy. Therefore, we focused on the possibility of invisible risk from the water that everyone drinks and utilizes. As mentioned earlier, this water may contain chemical and toxic substances, mixed with the water stored in Sariyatal lake. Therefore, there is a need to inform the villagers of this fact. Sariyatal

lake and the pumped-type well water source share the same underground water. However, villagers living higher on the mountain use water from the pumped-type well only, whose water quality is fairly different from that of Sariyatal lake. Most people at the foot of the mountain are not aware of this difference in quality.

In addition, villagers are also conscious of the water shortage problem because of increasing population in KT Hamlet and tourists, who utilize large amounts of water, as well as the higher precipitation during the summer season in this area. We did not find any evidence or solution for this issue in this survey. However, we believe that, instead of obtaining water from one source, as is the current practice, obtaining it from multiple sources can prevent water shortage. By doing this, the supply of water does not cease completely, allowing for a buffer to take measures, when there is a problem in the water supply path. A survey should again be conducted regarding water shortage.

Lastly, as we traced the water path, we could understand the actual situation and problems in KT Hamlet. There is a gap in the villagers' awareness and the actual situation. We need to inform the villagers of this fact at the earliest, to prevent these problems from becoming more serious.

Notes

1. <https://blogs.cdc.gov/publichealthmatters/2016/06/danger-in-the-water/> (accessed September 20, 2017)

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