Research article

Safety of Drinking Water Source and People's Choice Behavior in Rural India

SATO MORIO*
Graduate School of Frontier Sciences, the University of Tokyo, Chiba, Japan
Email: moriozisan@gmail.com

YAMAJI EIJI
Graduate School of Frontier Sciences, the University of Tokyo, Chiba, Japan

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Abstract The objective of this study was to reveal the causes of damages by diarrhea in India. In particular, this study focused on the safety of drinking water sources and people's preference for it in rural India because spread of toilets is difficult there at the moment. Two villages in Andhra Pradesh, India were selected as survey sites of this study. Concentrations were measured for coliforms, general bacteria and iron in all water sources and surface waters. Interviews and questionnaire surveys were conducted at a public school in the village. People in one village used wells and hand pumps while people in another village used a pond for drinking purpose. It was revealed that pump was the safest water source according to the results of measuring concentration of coliforms. Pond water, which is a surface water source, and well water, which is drawn from unconfined aquifers, were all contaminated by excreta. On the other hand, pump water, which is pumped up from confined aquifers and can be defined as safe water, was not contaminated considerably. However, people did not have proper risk perceptions and tended to hesitate to drink pump water because of its metallic taste and smell. Actually, concentration of iron of pump water was higher than those of the others. The pond and wells represented a high risk of diarrhea and it was difficult to improve them because hygiene education was not enough at schools; thus wide spread of toilets seemed difficult. In order to encourage people to use pumps, they should be made of materials which do not erode and affect the taste and smell of water. It is also important that people have proper risk perceptions about each water source.

Keywords drinking water, toilet, sanitation, hygiene, diarrhea, India

INTRODUCTION

About 1.5 million children of age five and below die from diarrhea every year. This is the second cause of death for children (WHO, 2008). The most seriously affected country is India, in which about 0.39 million children die from diarrhea (UNICEF and WHO, 2009).

Pathogens which cause diarrhea are spread from excreta to new patients through hands, animals, water, etc. (Carr et al., 2001). Building toilets, developing water sources, improving water quality, and improving hygiene habits can reduce the risk of diarrhea relatively (Fewtrell, 2005). In order to prevent children's death by diarrhea, the United Nations set a goal to "halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation" in Millennium Development Goals (MDG), and many kinds of activities were conducted all over the world. But in India, especially in rural areas, about 79% of people still do not have basic sanitation and 69% do open defecation (WHO and UNICEF, 2010). Previous researches indicate that this is because people are not in the habit of using a toilet (Banda et al., 2007), and that building a toilet is too expensive for them (Jha, 2003).

The objective of this study was to reveal the causes of damages by diarrhea in India. In particular, this study mainly focused on the safety of drinking water sources and people's

preference for it in rural India. It is very important to keep safe drinking water sources and use them properly in rural India, where usage of toilets is difficult to spread.

METHODOLOGY

Two villages (P-village and T-village) near Sompeta city of Srikakuram district of Andhra Pradesh state of India were selected as survey sites of this study (Fig. 1). Andhra Pradesh state is in the southeastern part of India, and its average income is Rs 23,700 which is almost equal to that of the entire India, Rs 23,200. 21.9% of the population in the urban areas as well as 81.9% in the rural areas, do not have a toilet at home. The percentage in rural areas is higher than the average of all of India; 78.1%. Sompeta city has a population of 17,400; it is the smallest of all 6 cities in Srikakuram district. P-village is about 1.5km away from Sompeta city and T-village is about 13km away from it. On-site survey was conducted from 28th October to 11th November in 2011. The survey consisted of a water quality survey, interview survey, and a questionnaire survey.

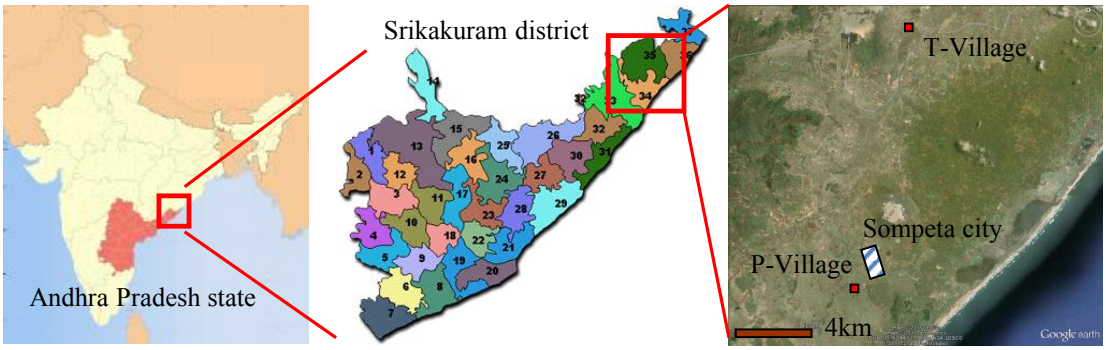

Fig. 1 Survey site

In water quality surveys, concentrations of coliforms, general bacteria and iron of each water source were measured on 21 points of P-village and 15 points of T-village (Fig. 2). Two hand pumps in T-village, 'Y' and 'Z', could not be measured because they were broken. The types of points measured were hand pumps, public wells, private wells, a container, ponds, and streams. Hand pumps, public wells and containers were supplied by Rural Water Supply, which is a state department. Public wells were the oldest water facilities and hand pumps were the newest ones. Container was a huge water tank with some taps at the bottom. Private wells were a kind of wells which were ordered individually and built at people's houses. Some private wells were built inside the houses while others were outside. The number of people who had private wells was increasing over the duration of the survey.

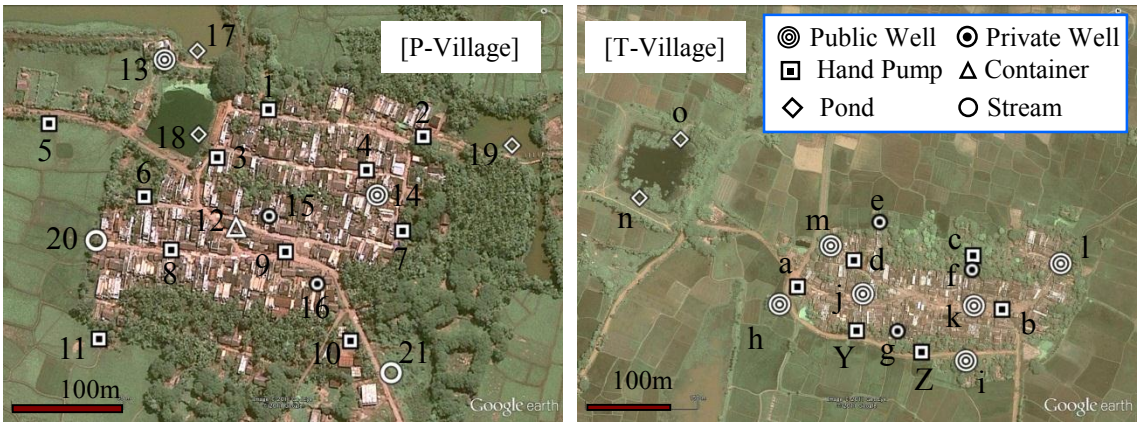

Fig. 2 Points of water quality survey in P-village (left) and T-village (right)

For measuring concentrations of coliforms and general bacteria, 1 mL of sampled water was dropped on a detection paper and put into a cultivator which was kept at 37℃ for about 24 hours

for cultivating coliforms and general bacteria. The detection paper was SUNCOLI produced by Sun Chemical Co. Ltd., and the cultivator was CB-101 produced by Sibata Science Technology Ltd. For measuring concentrations of iron, a test kit of WAK-Fe produced by Kyoritsu Chemical-Check Lab. Corp. was used. Furthermore, whether residents who lived near each water sources use it for drinking or not were checked through interviews.

Questionnaire and interview surveys were conducted at a public school in P-village. In this area, children from 1st grade (6 years old) to 5th grade (10 years old) go to a primary school, and children from 6th grade (11 years old) to 10th grade (15 years old) go to a high school. Compulsory education is conducted at primary and high school for ten years. Most children go to a public school in the village free of charge while others go to a private school in a nearby city. P-village has both a primary and a high school, but T-village has only a primary school. Children in T-village go to a high school in a neighboring village.

Questionnaire survey was applied to 13 years old 8th grade children, at a public school in P-village (n=31). Questions focused mainly on the use of drinking water sources and toilets, diarrhea frequency, etc. On the other hand, 10 years old 5th grade children were asked only one question: whether they have a toilet in their house or not (n=14). School teachers were interviewed about hygiene education at school.

RESULTS AND DISCUSSION

Use of water sources

Table 1 shows the number of water sources and whether they are used for drinking or not. In P-village, hand pumps, private wells and a public well at a temple are used for drinking purpose. Among these, the temple well was used frequently. However, other public wells, the container, and ponds are not currently used. On the other hand, most of people in T-village use the pond as drinking water source, and few people use pump or private wells. Public wells, except the temple well, are not used for drinking.

Table 1 Number of water sources and their use as drinking water

	P-Village		T-Village	
Water Source	Drink	Not Drink	Drink	Not Drink
Public Well	1	1	1	5
Private Well	2	0	3	0
Hand Pump	10	1	4	0
Container	0	1	0	0
Pond	0	3	1	0

Safety of drinking water sources

Fig. 3 shows the results of measuring concentrations of coliforms at P-village and T-village. Marks above numbers and alphabets show whether the water source was used for drinking or not. A circle means it was used for drinking and a cross means it was not. A triangle means few people drink it and a double circle means it was the most popular drinking water source. Only hand pump fulfilled WHO's guideline of drinking water quality that specifies coliforms should not be found in 1mL of sampled water. Nevertheless coliforms were detected in 4 pumps of 11 in P-village and in 3 pumps of 4 in T-village. Coliforms were also detected in all other water sources including well and pond which people used as drinking water sources.

Water from public and private wells are drawn from unconfined aquifers, thus it is easily affected by surface water. According to the results, surface water and well water of this area was contaminated by excreta. It was revealed that many people use ponds and well water for drinking, even though they are not safe.

On the other hand, water from hand pumps comes from confined aquifers that are difficult to be affected by surface water and can be defined as safe water which is not contaminated. However,

coliforms were detected in some pumps. This may be because some pipe parts of the pump were corroded and perforated and hence contaminated water mixed with pump water. Pump water was safer than other sources, but it was not completely safe and a risk of diarrhea exists.

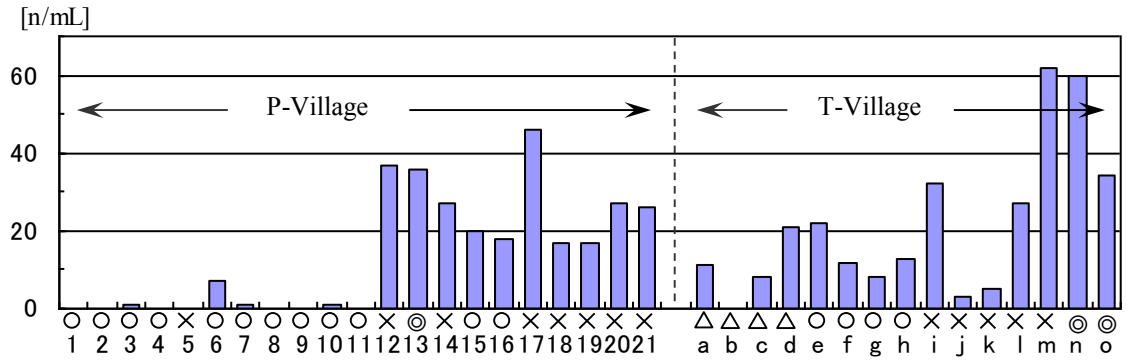

Fig. 3 Concentrations of coliforms on water sources

Possibilities of improving surface water from the point of view of hygiene education

Fig. 4 shows percentage of children whose houses were equipped with a toilet. More than 70% of children do not have a toilet at home, but most of them want one. As a reason, 76% selected "convenience". More than two out of three defecates in open spaces, and 42% in the class excrete near a pond. For the images of open defecation, 80% selected negative keywords like "dirty", "ugly", "inconvenient", and "shameful", but 13% selected positive keywords like "good feeling" and "cleanliness". Many children recognized open defecation as negative, and wanted a toilet for convenience.

There were two toilets at the public school in P-village, but children could not use them because they were broken and locked. According to the interview with the school teacher, children had used toilets properly in the beginning, but they gradually stopped using them properly, and toilets had become broken. This is because toilet users had to carry water from a hand pump, which was 50m away from toilets. When children feel the need to defecate at the school time, they have to endure or go outside.

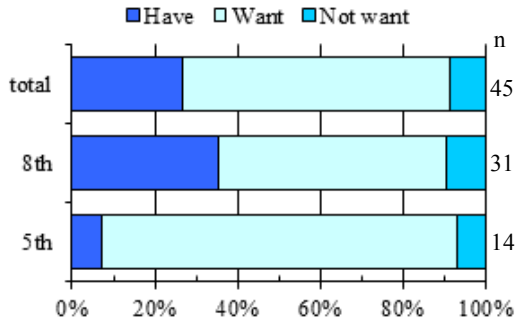

Fig. 4 Percentage of children whose houses are equipped with toilets

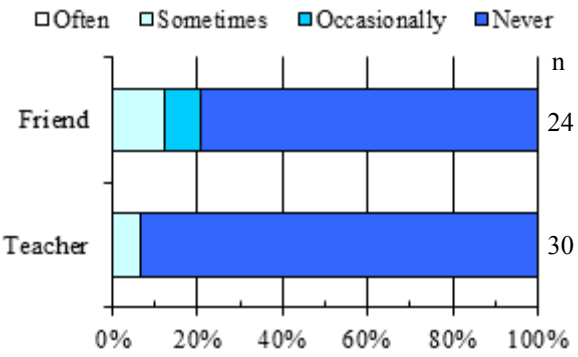

Fig. 5 Frequency of instruction to use toilet by friends or teachers

Teachers said that they taught children how to use a toilet when they taught hygiene. However, they also said that it was difficult to teach about toilet in daily life because they were broken. Fig. 5 showed frequency of instructions to use a toilet by friends or teachers. Most of the children did not realize that they were instructed about the usage of toilet at school. From the above reasons, it can be inferred that education about toilets was not conducted enough at school, and this is one of the factors that prevented the spread of toilets. Therefore, it is difficult and likely to take a long time to improve water quality of surface water.

Factors that influence people's choice of drinking water sources

According to the questionnaire survey at the public school of P-village, 52% of children used wells for drinking purpose and 32% of children used hand pumps. Fig. 6 shows the percentage of children who hesitate to drink water from wells and hand pumps. More than 40% of children hesitate to drink water from pumps. The most common reason was because of its "taste" and "smell". No one selected "location" as a reason. Less than 20% of children hesitate to drink water from wells. The most common reason was "family and friends do not use". "Safety/ dirtiness" and "location" were not selected.

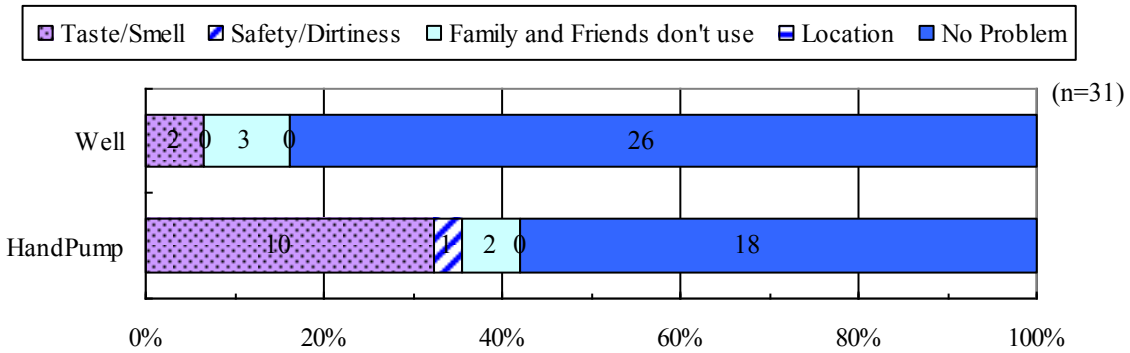

Fig. 6 Percentage of children who hesitate to drink water from wells and hand pumps

In T-village, most people used pond water for drinking purposes. They mentioned a better taste as the reason. They tended to dislike especially drinking water from pump because of its metallic taste. However, few people think pond was safe for drinking, and so they built and use private well or used pump for preserving their health.

Fig. 7 shows the results of measuring concentrations of iron at P-village and T-village. Marks above numbers and alphabets show whether the water source was used for drinking or not. For 'Ponds' and 'Wells', the average value was considered. In WHO's guideline of drinking water quality, there is a reference value about iron from a viewpoint of taste and coloring, though not from a viewpoint of safety. It specifies that concentrations of iron should be under 0.3mg/L. Higher levels of iron than the reference value were detected in some pumps. Two pumps of 11 in P-village and 3 pumps of 4 in T-village had higher levels. Particularly, values measured in pumps of T-village were very high; the highest being above three times the reference level. However, all other kinds of sources had a lower level than the reference value. Pump named '5' has been used for hand washing instead of drinking because it is located near a pond where many people practice open defecation.

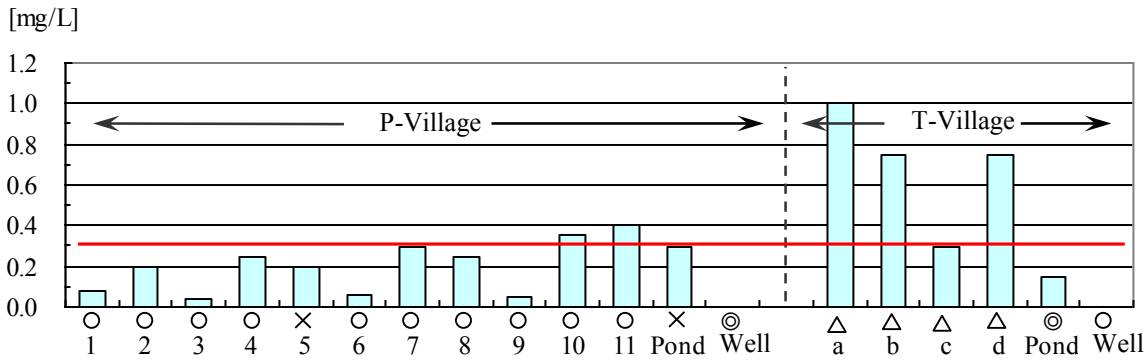

Fig. 7 Concentrations of iron in hand pumps, average of ponds and average of wells

People who did not have proper risk perception about each water source tended to choose by its taste and smell. Pump was the safest water source in this area, but many people hesitate to drink it. It was clear that this was caused by high concentrations of iron.

CONCLUSION

Water from ponds and wells used by many people for drinking contained many coliforms, and the risk of diarrhea by drinking water from ponds and wells is higher than that of hand pumps. It seems that it will take a lot of time to improve water quality of ponds and wells by spreading toilets because hygiene education was not conducted enough at school although most of children regarded open defecation negatively and wanted toilet in their homes.

Hand pumps are theoretically safer because the water comes from confined aquifers, which are difficult to be contaminated by surface water. However, coliforms were detected from some pumps on the actual site. In order to keep and use pumps as a safe drinking water source, regular inspection of water quality is needed.

However, people did not have proper risk perception about each drinking water source, and they chose and used source by other factors like taste. People especially hesitated to drink water from pumps, which was safer than others, because its concentration of iron tended to be high and its taste and smell got worse. Pump should be made of material which does not erode and affect the taste and smell of water. It is also important for people to have proper risk perception about each drinking water source in order to stop using unsafe water and then reduce the risk of diarrhea. Future studies should investigate ways to disseminate a proper risk perception among people to change their behavior.

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