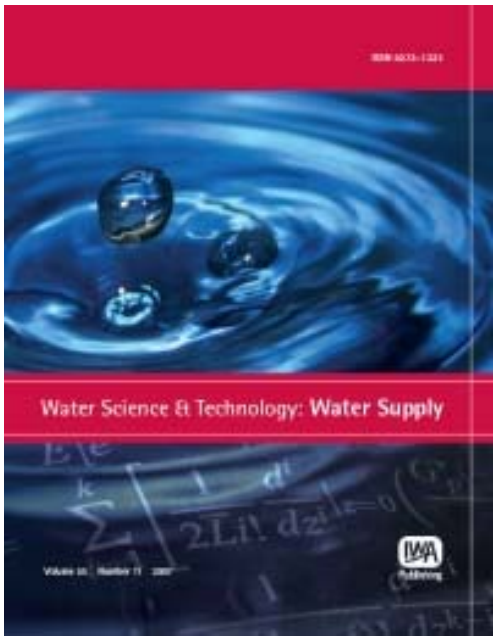


Empowering rural communities: simple Water Safety Plans

T. J. Hasan, A. Hicking and J. David

ABSTRACT

Every year 2800 deaths in Pacific island countries result from diarrhoea, and most are children under five years of age. These tragic diarrheal deaths are preventable as they are often linked to unsafe water, lack of proper sanitation facilities and poor hygienic practices. Effective preventive management through the framework of a drinking Water Safety Plan (WSP) is an efficient mechanism for ensuring the safe quality of drinking water thereby reducing the burden of water related diseases. The large proportion (81%) of people in Pacific island countries living in rural or outer island communities mostly have their own water supply (for example rainwater tanks or hand-dug wells), and often the water is consumed untreated. The remoteness and isolation of these rural communities prevent national surveillance authorities to regularly visit and provide advice on drinking water safety issues. In such circumstances empowering rural communities to ensure the safety of their drinking water, through trained local facilitators, could be promoted and utilised effectively. However, WSPs for rural communities have to be relatively simple hence tools such as modified sanitary inspections and the presence/absence hydrogen sulfide test could be used. The approach of empowering communities through trained local facilitators to promote the WSP framework has been implemented in the Republic of Marshall Islands (RMI). Positive feedback has been received by trained facilitators in RMI on the use of modified sanitary inspections (translated into Marshallese) and the hydrogen sulfide test. It is believed that the approach of empowering communities on WSPs through training local facilitators and equipping them with the above mentioned simple tools is effective and has potential for further replication in rural Pacific communities to improve drinking water quality and reduce the burden of water related diseases.

Key words | hydrogen sulfide test, pacific Island countries, Republic of Marshall Islands, rural communities, sanitary inspections, Water Safety Plans

T. J. Hasan (corresponding author)
Water and Sanitation Programme,
Pacific Islands Applied Geoscience Commission,
Mead Road,
Suva,
Fiji Islands
E-mail: *Tasleem@sopac.org*;
tazhasan@yahoo.com

A. Hicking
Environment Protection Agency,
Delap Lagoon Road,
Majuro,
Republic of Marshall Islands

J. David
Land Grant,
College of Marshall Islands,
Arrak,
Majuro,
Republic of Marshall Islands

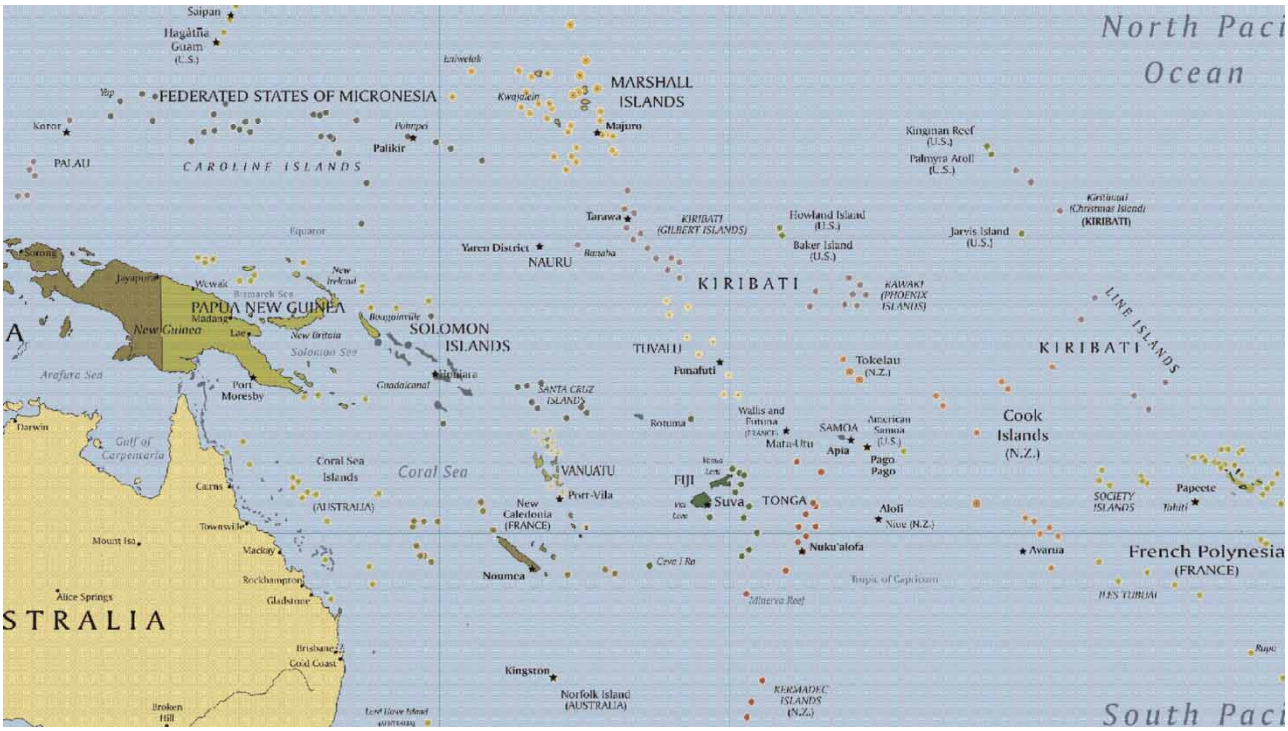
INTRODUCTION

Access to safe drinking water is a basic human need and essential to public health. The resolution of the 64th United Nations General Assembly declared the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights (UN News Centre 2010). However, illness and death arising from drinking unsafe water has continued to impact communities throughout the world and the Pacific.

Pacific island countries (including Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Republic of Marshall Islands, Nauru, Niue, Palau, PNG, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu) (see Map 1) have uniquely fragile water resources due to their small size, lack of natural storage, competing land use, and vulnerability to natural hazards (including climate change) and human activities (Overmars & Gottlieb no date). The island countries are vastly scattered and spread across 180 million square kilometres of the Pacific Ocean, which represents about 30% of the world surface (WHO & SOPAC 2008).

Although they differ significantly in size, population and resources endowment, the Pacific island countries share

doi: 10.2166/ws.2011.051



Map 1 | Pacific island countries.

many common development constraints and challenges, including a limited human and financial resources base and lack of safe and adequate drinking water and sanitation services.

The Pacific region's access to improved drinking water and sanitation lags behind the rest of the world. Only about 46% of Pacific populations have access to improved drinking water sources (piped water into dwelling, plot or yard; public tap/standpipe; tubewell/borehole; protected dug well, protected spring; and rainwater) compared to the global average of 87% (WHO & SOPAC 2008). Every year 2800 deaths in the Pacific region result from diarrhoea, and most are children under 5 years of age (WHO & SOPAC 2008). These tragic diarrheal deaths are preventable as they are often linked to unsafe water, lack of proper sanitation facilities and poor hygienic practices. For example, the reduction in diarrhoeal diseases due to intervention in the areas of water supply and water quality are 25 and 31% respectively (Prüss-Üstün *et al.* 2008).

Effective preventive management through the framework of a drinking Water Safety Plan (WSP) is the most effective means of consistently ensuring the safety of a drinking water supply thereby reducing the burden of water related diseases. A Water Safety Plan is a 'comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer' (WHO 2004). Water Safety Plans have a high degree of flexibility and thus are applicable to any water supply from individual systems to small community systems to large utilities. The approaches for implementation of WSP can differ; however, the risk assessment and management principles ensuring safety of drinking water supplies are consistent.

Almost 81% of the Pacific population live in rural or outer island communities (WHO & SOPAC 2008). The drinking water sources for these communities vary but mostly include river water, bore/well water, spring water and rainwater. Drinking water is accessed either individually (household) or through a community managed supply and is most often consumed untreated. These community managed water supplies or individual household water supplies in rural and outer island settings in the Pacific present special challenges. The remoteness and isolation of

these rural communities prevent national surveillance authorities to regularly visit and provide advice on drinking water safety issues.

Using a case study from the Republic of Marshall Islands, this paper discusses the merits of promoting WSPs and empowering communities to keep their water supply safe through using the approach of training local facilitators and equipping them with simple tools such as the sanitary inspection and the presence/absence hydrogen sulfide test.

METHODS

Promoting WSPs to rural and outer island Pacific communities where generally the populace is non technical and have limited formal education is challenging. The scientific and technical knowledge on offer through experts can at times be difficult to transfer to rural communities, especially if there is a language barrier between the experts and the community. There are approximately 1,000 different languages spoken across the rural areas of the Pacific (WHO & SOPAC 2008).

Hence the approach of training local facilitators in each country for promoting the WSP concept is recommended. For example, to promote WSP in rural settings of the Fiji islands local Fijian facilitators should be trained; for promoting WSP in rural areas of Samoa, local Samoan facilitators should be trained and so on. It should be ensured that the facilitators speak the local dialect hence for larger island countries such as Papua New Guinea, local facilitators will be district or province specific. The local facilitators can include local non government organisations (NGOs), health inspectors, environmental officers, community extension workers, community champions and the like. It is essential that the facilitators have a good relationship with the communities and that there is mutual respect. The local facilitators should then be appropriately trained on the WSP approach and equipped with simple and effective tools to assist them to engage with the communities in a participatory manner. The two tools recommended for use in this paper are sanitary inspections and the presence/absence hydrogen sulfide test; the hydrogen sulfide test in this paper refers to the commercially available PathoScreen test (HACH no date). There is also a hydrogen sulfide paperstrip test that can be locally produced (Mosley & Sharp 2005)).

Sanitary inspection

A great strength of drinking WSPs is the applicability of the risk assessment and risk management approach to any water supply system (large or small). Experiences from introducing WSPs internationally show that providing guidelines or templates to trigger the thinking process on risk assessment and risk management is a useful tool. These templates however, are mostly for large water supply settings as compared to the situation found in rural Pacific communities.

As part of the implementation of their drinking water safety and quality programmes, SOPAC (Pacific Islands Applied Geoscience Commission, www.sopac.org and www.pacificwater.org) and the World Health Organization (WHO, South Pacific office) promote the use of sanitary inspections as simple WSPs for rural or outer island settings. Sanitary inspections were introduced in Volume 3 of the WHO Guidelines for drinking-water quality for use during surveillance and control of community water supplies (WHO 1997). Sanitary inspections are designed to provide an overview of the status of risk (microbiological in particular) of the supply to contamination.

Sanitary inspections can be made to monitor the potential for contamination in the future, thus providing an early warning function and a chance to fix or rectify the problem before contamination occurs, synonymous to the WSP approach. The questions in a sanitary inspection are usually structured so that the answer is either 'yes' or 'no'. 'Yes' relates to a potential risk that could contaminate the water supply. The process of filling in the sanitary inspection is the risk assessment and taking corrective actions to convert the 'yes' into a 'no' is the risk management.

For example, for a rainwater collection and storage system, having dirty guttering channels through accumulation of dust, dirt, leaves, dead insects and bird droppings is a potential risk that will contaminate rainwater collected from the channel. The sanitary inspection question relating to this potential risk would be: "Are the guttering channels that collect water dirty? Y/N."

The risk management resulting from this would be to maintain the cleanliness of the guttering channels.

Since microbiological quality of drinking water is of principal importance because of the acute risk to health posed by bacteria and viruses, the sanitary inspection is a very useful tool for use in rural or outer island communities in Pacific islands.

Hydrogen sulfide test

The other challenge of promoting WSPs is to culture behaviour change. WSP is a shift from the traditional reactive approach of fixing something when it goes wrong to the pro-active approach of identifying the issue and taking action before it becomes a problem. Often rural communities do not keep their water supplies safe, for example, a rainwater harvesting system requires simple steps such as cleaning of roof and guttering and periodic cleaning of inside of the tank to maintain the safety of drinking water. However, communities only take action if the national surveillance agency visits them and recommends the tank to be cleaned or if they suspect a gastrointestinal disease has resulted from their drinking water.

The use of the simple presence/absence hydrogen sulfide test, coupled with sanitary inspections, can be used to provide the impetus for implementing the WSP approach. The hydrogen sulfide test detects hydrogen sulfide producing bacteria such as *Salmonella, Citrobacter, Proteus, Edwardsiella* and some species of *Klebsiella* (Mosley & Sharp 2005). If you test a water sample contaminated with hydrogen sulfide producing bacteria using the test then the color of the water will change from yellow (original color due to reagents) to black within two days – very visual and the people can see the change first-hand as opposed to laboratory-based results.

The visual color change impacts people and instantly captures their attention, and they then want to take action to make their drinking water safe and free from contamination. This gives an ideal impetus to introduce the WSP framework (sanitary inspection). The test is promoted for use in remote and isolated rural communities in the Pacific because of its ease, simplicity, low cost and most of all visual basis (Mosley & Sharp 2005). In addition, it has been shown that hydrogen sulfide producing bacteria are associated with faecal contamination (relatively good correlation) and can be used as indicator organisms (Tambekar *et al.* 2007).

CASE STUDY – REPUBLIC OF MARSHALL ISLANDS

The approach of empowering rural communities through training local facilitators to promote the WSP framework has been implemented in the Republic of Marshall Islands (RMI), that is, local Marshallese facilitators were trained to spread the WSP concept. RMI consists of two roughly parallel chains of 29 coral atolls and five single coral islands, mostly low coral and sand. The highest elevation is only 10 m above sea level, and average elevation is 2 m (SOPAC 2007). As with other Pacific countries, the island groups are highly scattered (refer to Map 1).

The RMI Environmental Protection Agency (RMI EPA) has the legal mandate to monitor the quality of drinking water and coastal water and provide advice on corrective actions as required. The main office of RMI EPA is located on Majuro atoll (main centre) with one other branch based on Ebeye Island (of Kwajalein atoll). However, their responsibility for water quality monitoring extends to rural communities and outer islands within the RMI group. RMI EPA is assisted with their outer island drinking water quality monitoring role by the College of Marshall Islands (CMI) Land Grant's water division. The water quality extension officer of CMI travels to outer island communities in collaboration with RMI EPA to perform water quality monitoring.

The common sources of drinking water for rural and outer island communities in RMI include rainwater harvesting and wells. RMI EPA and CMI have been using the hydrogen sulfide test, commercially referred to as the PathoScreen test, for their water quality testing. The traditional approach has been advising communities to use household bleach for water treatment based on the test results.

Upon request from RMI EPA in November 2009 and as part of their regional role on water and sanitation SOPAC and WHO agreed to provide technical assistance in strengthening the capacity of outer island drinking water quality monitoring. Local Marshallese facilitators were trained by SOPAC and WHO in March 2010 on using the sanitary inspection and hydrogen sulfide test as tools to empower communities with the WSP approach.

A three day community based drinking water safety planning and water quality monitoring training course, developed by SOPAC and WHO, was delivered to a range of local water stakeholders. These included RMI EPA, CMI, Ministry of Health, Majuro Water and Sewerage Company, NGO Marshall Islands Conservation Society, NGO Women United Together in Marshall Islands, Majuro local government, Internal Affairs, Economic, Planning and Statistics Office, church groups and high school representatives.

Structure of training course

The course package is divided into 8 modules which are highly interactive with group work sessions, presentation by the trainees and a field visit. The training course is delivered in English hence the target local facilitators are expected to be English literate. The package contains selected resource contents from the SOPAC and WHO developed community toolkit (Keeping your drinking water safe no date). Module 1 introduces the broader WSP concept of risk assessment and risk management approach to ensuring the safety of drinking water. Module 2 explains how the WSP approach is implemented using the simple sanitary survey which can be modified to suit the circumstances of rural and outer island settings for individual or community water supplies. The use of the hydrogen sulfide testing kit as an impetus for WSP is covered in Module 3.

Module 4 explains how the results of the hydrogen sulfide test are interpreted within the WSP framework and appropriate remedial actions taken. Modules 5 and 7 train the participants to apply the theoretical knowledge from the previous modules out in the field (practical sessions), with community engagement and participation. Module 6 covers basic household water treatment processes to disinfect drinking water while remedial risk management measures are being put in place. The final module is a relatively simple written examination to gauge if the participants have grasped the concept of community-based drinking water safety planning and water quality monitoring.

Empowering communities

The training content focussed on adapting and modifying the WHO developed sanitary inspection forms for rainwater harvesting and hand-dug wells. The modifications to the sanitary inspection forms were done during the training course itself, drawing on the local settings and knowledge from the participants or local facilitators. For example, one question on the WHO rainwater harvesting sanitary inspection form (WHO 1997) is: 'Is there any deficiency in the filter box at the tank inlet (e.g. lacks fine gravel)?' The use of a filter box at the tank inlet is not practiced in RMI. Instead the use of wire screens at the inlet pipe is very common. Hence the particular question was modified to 'Is the tank inlet screen absent?' Similarly, the relevance of each question to the local circumstance was discussed and modified, as needed, with the facilitators during the training. A few additional questions which were not part of the WHO form such as 'Is the first flush device absent?' were added to the modified version in agreement with the facilitators. The important aspect to note is that modifications will need to be done in discussions and consultations with the local facilitators to capture the local settings and the national sanitary inspection form can vary from country to country depending on the local situation. The modified sanitary inspection forms for the RMI situation contain thirteen questions each for the rainwater harvesting system and hand-dug wells.

The core of the training was empowering communities to adopt the WSP concept through community engagement and participation when conducting sanitary inspections and water quality testing. It was highly recommended to use sanitary inspection forms translated into the local Marshallese language for effective community engagement and for the facilitator to use Marshallese dialect to impart the WSP concept.

The approach is for the local Marshallese facilitator to use the knowledge and resources from the training and visit individual households to educate them on links between water and health, importance of keeping water supply safe, hygiene practices and safe storage of water, sanitary inspection, the hydrogen sulfide test and simple household level water treatment methods.

The local facilitator then conducts the sanitary inspection with the household member responsible for the supply (man or woman), using the modified Marshallese

version. A copy of the sanitary inspection form is provided to the household member and the form is filled in in a participatory manner with discussions between the facilitator and household member. Both of them fill in their respective forms and the household member keeps their copy of the sanitary inspection form. A score of one point is allocated for every 'yes' and zero point for every 'no' answer. On completion the score of all 'yes' answers is totalled and recorded. The score indicates the number of actions which the household owner has to take in terms of risk management and is also useful to monitor progress. For example, if the initial score is ten out of thirteen (10/13) and then some of the risks identified as per the sanitary inspection form are addressed making the score five out of thirteen (5/13) then progress is being made. It is important to note that the scores are not being used to classify the risk into categories such as low risk or high risk relating to a particular score range. This is intentionally done to promote the management of all potential risks and avoid complacency by stating for example, that two out thirteen (2/13) is a low risk scenario.

At the end of the sanitary inspection, the water supply is tested using the hydrogen sulfide test. The household member is shown the yellow colour of the water sample and informed of the possibility of colour change to black if the sample is contaminated with bacteria. The local facilitator re-visits the household after 1 or 2 days (depending on the rate of colour change) with the water sample and discusses the results. If there are obvious risks to the water supply which had been noted in the sanitary inspection then it is highly likely that the water sample will turn black. This visual change in colour is expected to impact the household member and provide the impetus to take action on rectifying the risks from the sanitary inspection. Spare copies of the modified and translated sanitary inspection forms are left with the household member to conduct the inspection and manage the risks to their water supply at least once every 2 months. The local facilitator returns annually to the household to monitor changes to the sanitary inspection scores (if the score is lower on the return visit as compared to the original score then it indicates that actions are being taken to manage the risks) and discusses or advises on drinking water safety issues.

RESULTS AND DISCUSSION

The training course facilitated by SOPAC and WHO for the RMI local facilitators in March 2010 was successfully conducted. A total of 23 males and 8 females, from local stakeholders (as outlined above) were trained. These stakeholder agencies are all based on Majuro atoll; however, their work entails engagement with all communities in RMI regarding water supply, sanitation and hygiene issues. The aim of the initial course was two-fold, being (a) to train local facilitators based in agencies that serve the wider community to spread the WSP concept; and (b) to become trainers themselves for replication of the course to outer island local facilitators as part of their agency's outreach role.

All the participants captured and appreciated the new approach of risk assessment and risk management for ensuring the safe quality of drinking water and managed to successfully pass the final module. The course was delivered in English by experts from SOPAC and WHO hence a prerequisite was that the participants were relatively well versed in the English language. The approach promoted is to train local facilitators in the respective country, in this example local facilitators from Majuro in RMI, to understand, appreciate and implement the concept of WSP. The local facilitators are then encouraged through Modules 5 and 7 of the training course to use local language to engage with communities and spread the WSP concept. The outcomes from the RMI training course are discussed below.

Translation of sanitary inspection forms

It was recommended that the modified sanitary inspection forms are translated into the local Marshallese language by the RMI EPA education and awareness section and circulated to all stakeholders for comments before finalisation. The sanitary inspection forms for both the rainwater harvesting and the hand-dug wells have been translated and endorsed by all stakeholders who attended the training. It is electronically available for use by the stakeholders as required with a backup copy available at RMI EPA, SOPAC and WHO. The example below shows the translation of an excerpt from the English version of the modified rainwater harvesting sanitary inspection form

into the Marshallese language (Modified rainwater collection and storage sanitary survey form no date).

English version	*Marshallese version*
Is there any visible contamination on the roof catchment area (plants, dirt, excreta etc)? Y/N	Ewor ke men ko rej komman etton eon mweo (menin eddok, menoknok, bwidrej in menin mour ko, im ko jet)? Aeet/Jaab

The RMI counterparts are now exploring opportunities to have the resource materials of the training content translated into Marshallese as well for widespread dissemination and use.

Replication of course to train more local facilitators

The course materials were left with RMI EPA for replication of the training to other atoll islands within the RMI group to increase the pool of local facilitators and spread the WSP approach. At least one trained local facilitator per atoll island is considered a positive start. Two major training courses have been delivered in partnership between RMI EPA, CMI and EPPSO (initial trained facilitators) in the month of May 2010.

1. On Ebeye island with close to 40 participants from the Kwajalein atoll including Ebeye, Big Buster, Bikiej, Carlos, Lib, Little Buster, Mejato and Santo. The participants were from Health, Environment, local government, church groups, NGOs, youth groups and school representatives.
2. On Majuro atoll with one representative each from 16 different islands of Kili, Bikini, Ejet, Likeip, Jaluit, Namu, Wotje, Utrok, Namdik, Ujae, Ronlap, Ailuk, Maloelap, Wotho, Jabot and Majuro. The participants were from the local governments.

Community empowerment

RMI EPA and CMI are actively promoting the WSP concept and embarking on empowering the communities through the use of sanitary inspection and the hydrogen sulfide test after being trained through the course. The trained local personnel of RMI EPA and CMI facilitate the process in their local dialect using local jargon, knowledge of local settings, circumstances and cultural sensitivities and thus increase the chances of successful uptake of the WSP approach. This is believed to be the core for the future success of spreading WSP across RMI where the trained facilitators use their local language to engage with communities.

A few rural and outer island communities have been visited by the CMI extension officer including Laura (63 households), Woja (26 households), Jelto (7 households) and Rongrong (12 households) and the new approach of implementing WSP through community engagement by trained local facilitators conducted for rainwater harvesting systems. A return visit to some of the households from these rural communities was conducted after three months to assess the short-term sustainability of the approach. The return visits covered 39 households from Laura, 19 households from Woja, 6 households from Jelto and 8 households from Rongrong. All the households re-visited showed signs of risk management and improvement as per the sanitary inspection form; for example, the guttering and roof areas were cleaned, tank manhole was covered and the surrounding environment of tanks cleaned. This demonstrates that the approach of implementing WSP in the local language through trained local facilitators is effective and can produce positive outcomes.

It is still early to demonstrate the long-term sustainability of the approach as this needs monitoring over a longer period of time, however, the response so far has been overwhelmingly positive. Successive return periodic visits (annually) will confirm behaviour change by the communities towards the risk assessment and risk management approach of WSP. The provision of the sanitary inspection form (Marshallese version) to the household owners is vital to ensuring the momentum of WSP implementation at the community level for their rainwater harvesting systems.

The other trained facilitators are expected to follow and implement the approach in consultation with RMI EPA as the national surveillance authority. It has been agreed nationally that RMI EPA will provide the hydrogen sulphide test kit to the local facilitators during their visits. This would be a free of charge service provided by RMI EPA as part of their role to verify safe quality of drinking water to all people of RMI. In

addition, communities could also request the testing of their rainwater systems through a hydrogen sulphide test directly from RMI EPA. The link and partnership between SOPAC, WHO and the RMI counterparts is maintained for evaluating the approach, information sharing and discussions on drinking water safety and quality issues which arise. If successful, the empowering of rural communities will likely lead to improvements in drinking water quality and reductions in water related diseases such as diarrhoea.

CONCLUSION

The scattered nature of the islands and the limited human and financial resource base in the Pacific countries demand the shift from the traditional reliance on national surveillance authorities to empowering communities to keep their water supplies safe. It is believed that the approach of training local facilitators to promote the WSP concept to rural and outer island communities can be effective and successful.

The methodology undertaken by SOPAC and WHO is to deliver a training course in English to local facilitators to educate them on the WSP concept and community engagement through the use of sanitary inspections and hydrogen sulphide test. For example, to promote WSP in rural settings of Fiji Islands local Fijian facilitators should be trained. It should be ensured that the facilitators speak the local dialect hence for larger island countries such as Papua New Guinea, local facilitators will be district or province specific. The benefit of using local facilitators is that they will facilitate the WSP process in their local dialect using local jargon, knowledge of local settings, circumstances and cultural sensitivities and thus increase the chances of successful uptake of the WSP framework.

It was found that this approach of training local facilitators to empower communities is effective as shown by the case example of RMI. Local stakeholders from Majuro in RMI were trained as facilitators to understand, appreciate and implement the concept of WSP. These stakeholder agencies are all based on Majuro atoll; however, their work entails engagement with all communities in RMI regarding water supply, sanitation and hygiene issues. The Marshallese local facilitators were equipped with simple and effective tools such as the modified and translated sanitary inspection forms and the visual presence/absence hydrogen sulfide test for community engagement.

The results of the RMI study demonstrate that the approach of using local trained facilitators can be successful to spread the WSP concept of risk assessment and risk management. The national surveillance authority which in the case of RMI is the EPA, should remain the overall driver for the process and maintain their role in partnership with other local water stakeholders. The national surveillance authority should as part of their role ensure that the local facilitators are equipped with the translated sanitary inspection forms and hydrogen sulphide test kits during their community visits. It is recommended that the link and partnership with regional and international experts should be continued for training the local facilitators in the first instance and later for monitoring and evaluation of the process and sharing information on lessons learned for further replication.

It is believed that the approach of training local facilitators in the respective country to empower communities with the WSP concept is effective and has potential for further replication in rural Pacific island communities to improve drinking water quality and reduce the burden of water related diseases.

ACKNOWLEDGEMENTS

Sincere appreciation is extended to the SOPAC and WHO Pacific Drinking Water Safety Planning team for their support including Dr Marc Overmars (Manager, SOPAC Water and Sanitation Programme), Mr Alan Freshwater (SOPAC WSP Adviser), Mr Steve Iddings (WHO Environmental Engineer) and Mr Kamal Khatri (WHO Water Programme Officer). Special gratitude is expressed to Dr Luke Mosley (Principal Scientific Officer, Water Quality, EPA Adelaide, Australia) for reviewing the paper.

REFERENCES

HACH no date *Analytical Procedure, PathoScreen Field Kit.* Available from: http://www.pacificwater.org/userfiles/file/PathoScreen%20Test.pdf (accessed 16 August 2010).

Keeping your drinking water safe: a community toolkit no date Available from: http://www.pacificwater.org/pages.cfm/water-services/water-sanitation-hygiene-programme/water-supply/iec-materials-guidelines-hydrogen-sulphide-test-kit-manual (accessed 16 August 2010).

Marc Overmars & Sasha Beth Gottlieb no date Perspectives on water and climate change adaptation: Adapting to climate change in water resources and water services in Caribbean and Pacific small island countries. SOPAC Joint Contribution Report 195. SOPAC Secretariat, Suva.

Modified rainwater collection and storage sanitary survey form no date Available from: http://www.pacificwater.org/userfiles/file/Modified%20Rainwater%20Sanitary%20Survey%20Form.pdf (accessed 16 August 2010).

Mosley, L. M. & Sharp, D. 2005 *The hydrogen sulphide test: a simple test for monitoring drinking water quality in the Pacific islands*. SOPAC Technical Report 373. SOPAC Secretariat, Suva.

Prüss-Üstün, A., Bos, R., Gore, F. & Bartram, J. 2008 *Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health*. World Health Organization, Geneva.

SOPAC 2007 *National Integrated Water Resources Management Diagnostic Report: Republic of the Marshall Islands*. SOPAC Miscellaneous Report 639. SOPAC Secretariat, Suva.

Tambekar, D. H., Hirulkar, N. B., Gulhane, S. R., Rajankar, P. N. & Deshmukh, S. S. 2007 Evaluation of hydrogen sulphide test for detection of fecal coliform contamination in drinking water from various sources. *African Journal of Biotechnology* **6** (6), 713–717.

UN News Centre 2010 Available from: http://www.un.org/apps/news/story.asp?NewsID=35456&Cr=sanitation&Cr1 (accessed 11 August 2010).

WHO 1997 *Guidelines for Drinking-Water Quality*. 2nd edition, Vol. 3. World Health Organization, Geneva.

WHO 2004 *Guidelines for Drinking-water Quality*. 3rd edition, Vol. 1. World Health Organization, Geneva.

WHO and SOPAC 2008 *Sanitation, Hygiene and Drinking-Water in the Pacific Island Countries: Converting Commitment into Action*. World Health Organization, Geneva.

First received 20 December 2010; accepted in revised form 23 May 2011