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SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

Challenges of tsunami and conflict affected rural water supply in Sri Lanka

R. Saltori and A. Giusti, Sri Lanka

The water supply of the rural coastal areas in Sri Lanka is provided by private open dug wells, most of which have been flooded by sea water during the tsunami. The salinity of the well affected proved not to be the main problem, and early attempts to rehabilitate wells failed. Salinity reduction can only be achieved naturally, through the recharge of the aquifer. The true challenge for rural water supply is represented by bacteriological and agricultural contamination and sustainability of handpumps. Constructing back better means also an exit strategy from water trucking that does not focus on salinity, but introduces a new water quality awareness, and new water purification solutions, to the users. A lesson learned: in case of tsunami, do not try to rehabilitate the well, just wait for the rainy season.

Water quality

The water supply of the rural coastal areas in eastern and, to a minor extent, southern Sri Lanka is provided by private open shallow dug wells, normally 3 to 5 meters deep, most of which have been flooded by sea water during the tsunami. The quality of groundwater of the coastal aquifers is therefore a major concern for planners and agencies involved in water and sanitation.

Salinity

Few systematic salinity measurements are available for the immediate period after the flooding: however, reports from practitioners involved in the early stages of the disaster permit the following reconstruction of events (Fig. 1):

- A few days after the tsunami levels of salinity in wells reached conductivities up to 25,000 – 28,000 µS/cm, close to sea-water levels
- After few weeks (February 2005) most of the wells were at levels close to 3,000 - 8,000 µS/cm

Some organizations started to monitor systematically the salinity of wells during spring 2005. The ICRC has been monitoring 50 wells in Enchelappatu Division, Trincomalee District, since June 2005. The monitoring is still in progress, and the 1 year series is shown in Fig. 2.

The analysis of these data shows how salinity in the wells remained more or less constant, with minor fluctuations, throughout the dry season. With the rains of October-November 2005, the average SWL of the wells under observation rose approximately 1 m, while the average conductivity dropped from 3,500 to 1,700 µS/cm. During the dry period of the first half of 2006, the conductivity remained more or less constant.

The first peak of contamination, with extremely high salinity levels, is certainly due to the temporary presence in the wells of seawater that eventually spontaneously infiltrated the aquifer. The ensuing higher-than-normal levels are due to the medium term salinisation of the coastal aquifer itself, with mechanisms of contamination that have been extensively described in several papers (UNICEF, 2005, IWMI, 2005, Illangasakare et al., 2006). All authors agree that the full recovery will be achieved only with the natural recharge of the aquifer after one, or more, rainy seasons. Data from the ICRC monitoring confirm this assumption.

Bacteriological quality

Most of the tsunami affected drinking wells are shallow, usually unprotected and located in highly populated areas. They are therefore very close to latrines that are mostly equipped only with soak pits, with no primary or secondary treatment. Virtually no centralized sewage and purification systems are present in eastern Sri Lanka. Under those circumstances, it is reasonable to assume that the quality of the water in the wells is at best questionable.

Random analysis of wells conducted by ACF on 122 wells in Batticaloa district show that 78% of the wells considered have a level of contamination from E-coli higher than 10 colonies per 100 ml (Table 1). A similar result was found

Table 1. Bacteriological analysis in 4 divisions of Batticaloa District (Source: ACF)

Ecoli/100 ml	N. of analysis	%
0 – 10	27	22
11-50	19	16
51-100	11	9
> 100	65	53
TOTAL	122	100

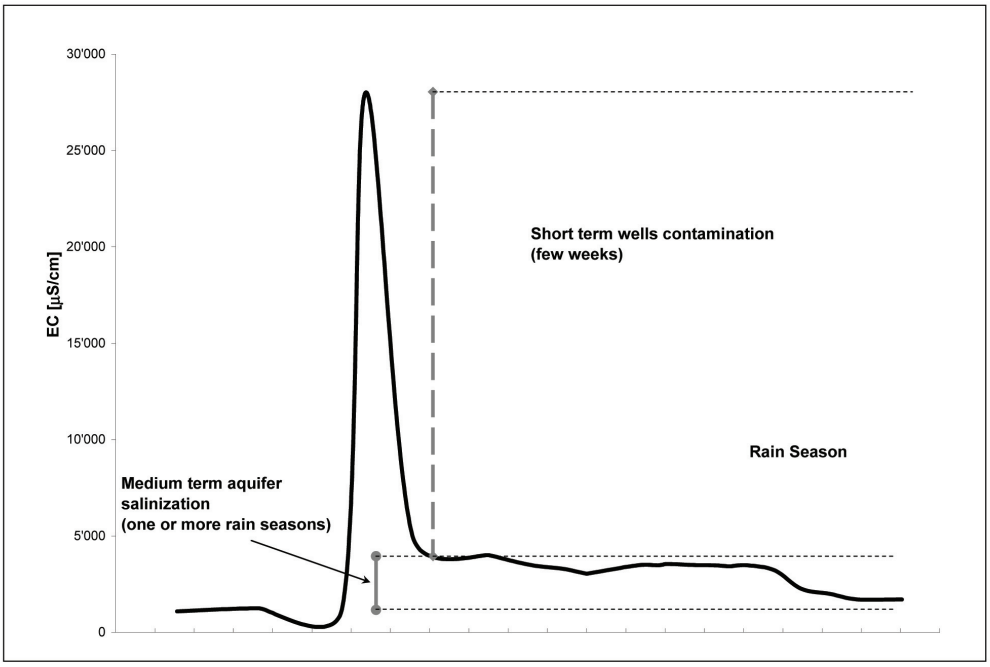

Figure 1. Variation of salinity vs. time in tsunami-affected wells

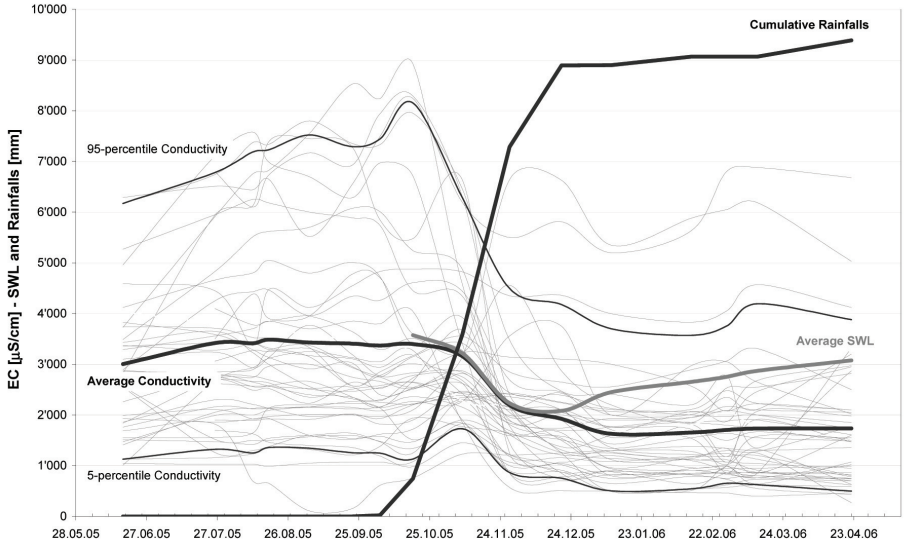

Figure 2. Variation of salinity, SWL and rainfall vs. time in 50 tsunami-affected wells (ICRC)

by HELP from Germany in Khinnia Division, Trincomalee District (Fig. 3).

A comprehensive and statistically representative country-wide research on bacteriological quality of wells is being conducted by ISS (Istituto Superiore di Sanita', Italy) in cooperation with MoH. The final report is still not available, but the preliminary results are in line with the aforementioned assessments.

Influence from agriculture

Vegetable gardening is an increasing source of income for the residents in coastal areas. There are a number of factors that suggest an increase in this pressure in the future including increased demographic density; diversification of livelihood

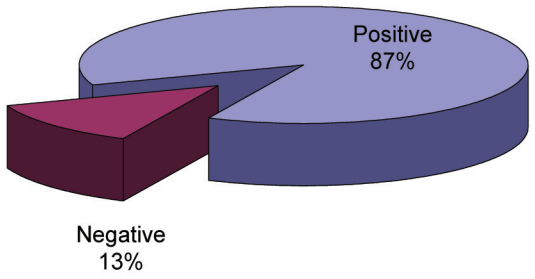

Figure 3. Bacteriological analysis in 23 wells in Khinnia Division - Trincomalee

Source: HELP from Germany

styles from fishing activities due to over-fishing and relocations after the tsunami; presence of sandy soils and availability of freshwater at a shallow depth, and distributions of a large number of motorized pumps from aid agencies.

All those factors will increase the pressure on the fragile coastal aquifers, with risk of saline intrusion from overpumping and contamination from nitrates and, possibly, pesticides. Preliminary results from water analysis conducted around the country (Italian RC, IWMI, UNICEF) suggest that contamination from agriculture is already taking place. UNICEF and FAO are conducting a study in two sample areas, on eastern and western Sri Lanka, to support the GoSL in defining a policy regarding agricultural practices compatible with the protection of the aquifers.

The humanitarian response

The tsunami triggered one of the largest relief operations in history. Provision of water via tankering and cleaning of wells from saltwater was perceived by many as a priority, particularly in the early days of the operation.

Rehabilitation of wells

In the first weeks after the tsunami, a large number of organizations, volunteers and armed forces extensively dewatered virtually all wells in range. Some wells have been pumped repeatedly by different actors, and the perception of the population was that the more a well is pumped, the faster, and better, recovery would be. Already in January 2005 both IWMI and UNICEF issued guidelines on well rehabilitation, stressing in this first version the need to avoid overpumping and well emptying, and to monitor the activities as a minimum with a conductivity meter. In March 2005, UNICEF Trincomalee disseminated, through the watsan coordination group, the first version of a paper containing recommendations on well rehabilitation and proper chlorination practices. By March, well dewatering operations were normally run by teams better equipped, trained, and aware of the risks of overpumping. Records of the rehabilitations were kept, and data started to be shared. Maps of the salinity were produced with data from different agencies (Fig. 4). In early May, a workshop on water quality and well rehabilitation was held in Trincomalee (Fig. 5) and replicated in Batticaloa, and the main organizations involved agreed on a common protocol and data sharing.

Data collection and sharing, and increased awareness of the field operators, gave a better understanding of the

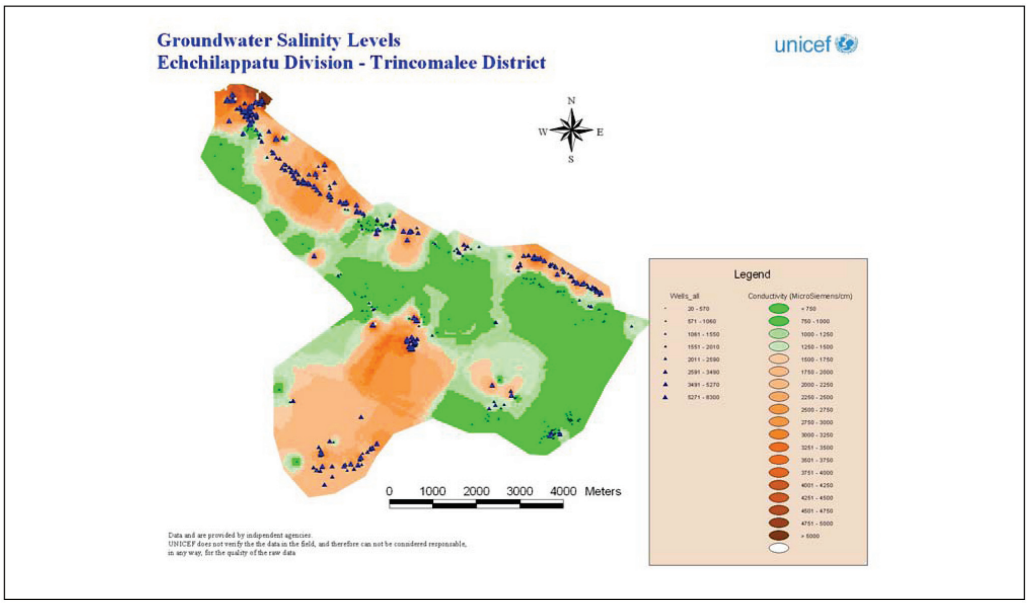

Figure 4. Salinity map, June 2005 (data ICRC). The coastline is upper right)

Figure 5. "Controlled" well dewatering operations

Photo: UNICEF

dynamics of the aquifer and the extent of the saltwater contamination. Practitioners in the field were aware that the pumping of wells did not achieve any substantial effect in decreasing the salinity (Fig. 6) except in exceptional cases. Nevertheless, reports from the field showed the importance of controlled pumping for the positive psychological effect it had for well owners.

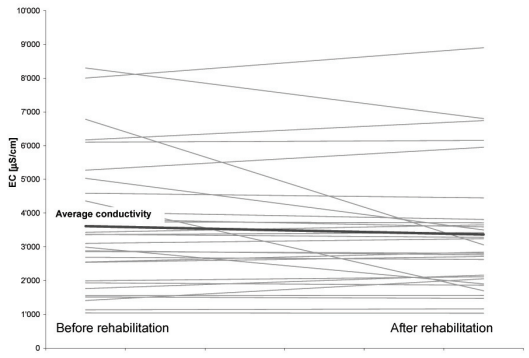

Figure 6. Salinity levels in 30 wells before and after rehabilitation – Enchelappatai Division, Trincomalee

Source: ICRC

In fact, the conductivity of many wells (Fig. 1, 6) was already at acceptable levels [(1)] according to national and international standards for salinity [(2)]. Nevertheless, the feeling of many well owners was that tsunami affected wells could not be used without strong dewatering. This feeling, albeit to a lesser extent, was still present one year later: in May 2006 according to an ACF assessment 14% of well owners in Ampara District felt that their well needed to be dewatered before use (ACF, 2006).

Emergency water supply

Water supply in the first phase of the emergency was provided by water tankering (bowsering). In all those areas where NWS&DB [(3)] could not provide filling stations, water was sometimes taken from wells whose salinity was even higher than the one of the area where the water was distributed. However, even if the taste was questionable, consumers normally assumed that bowsered water was safer, and consumed it. Within a few weeks emergency water treatment plants were established and began to supply most of the water transported by bowsers.

From March 2005 most of the tsunami victims within the buffer zone [(4)] were accommodated in Transitional Shelters Sites (TSS). Those sites, most of which still exist, were supplied with safe water in various ways. Where the network was available, the sites were connected by the NWS&DB. In other cases, the vast majority of camps are still serviced by water bowsers. Only a minority of TSS were equipped with wells and internal piped systems. In some Districts [(5)] water distributions continued also outside TSS, serving the resident population not necessarily affected by the tsunami.

Rehabilitation and construction of tube-wells equipped with hand pumps

A few months after the tsunami, some organizations started mechanical and hand drilling shallow-tube-wells equipped with hand pumps along the coastal area. Some other organizations are currently planning and launching important drilling campaigns for constructing hand pumps up to a distance of 15 to 20 km from the coast.

However, the protection from contamination provided by tube-wells tapping coastal aquifers is rather a "placebo" since the aquifers are so shallow that contamination from the surface is possible. Furthermore, the standardization of hand pumps is becoming an issue.

As for the hand pumps tapping "deeper" inland aquifers, as shown by an evaluation conducted by the ICRC in areas affected by ongoing violence in Ampara and Batticaloa districts, the sustainability of the hand pumps is undermined by the weakness of the so called "Three Tier Maintenance System"[(6)] (Fig. 7).

Lessons learned

No outbreak of water borne or water related diseases took place after the tsunami. Since this is the main indicator for the water and sanitation sector in emergencies, and in view of the extent of the destruction, we can consider the overall emergency intervention a success. The prompt and dedicated commitments of the staff of the NWS&DB, heavily supported by the International Aid Community, are the main reasons for this success.

Nevertheless, as always, some lessons can be learned and an analysis of the events can help to improve the effectiveness of the emergency operation.

Fig. 8, gives a visual indication of the timeframe of the activities that took place.

Well rehabilitation

During the early days and weeks after the tsunami, the rehabilitation of flooded wells was given the highest priority. In

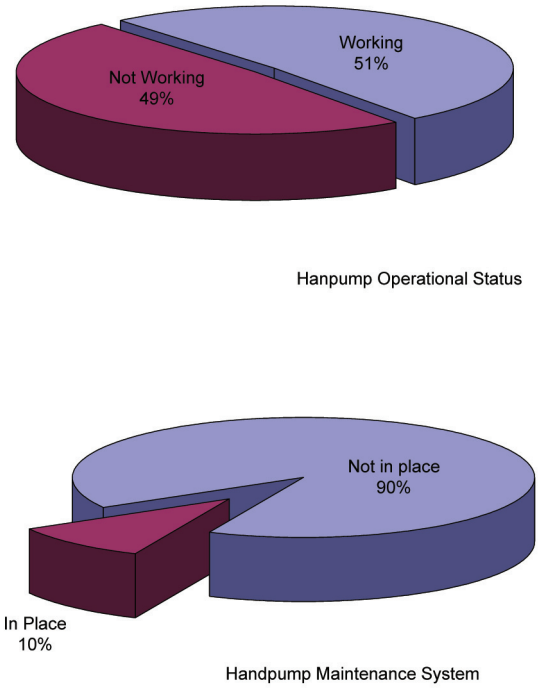

Figure 7. Evaluation of 96 hand pumps rehabilitated by the ICRC in Ampara and Batticaloa Districts between 1998-2002. 90% of the pump caretakers neglect their duty, 85% of the Consumer Societies are dissolved and the technical service provided by the Pradeshya Sabhas and the NWS&DB covered only 10% of the requirements.

Source: ICRC

areas where the water supply was guaranteed mainly through wells, this is a comprehensible concern. Even one year on, some critics argue that not enough has been done and that more resources should have been dedicated to this.

The experience in Sri Lanka clearly showed the contrary: the "well rehabilitations" conducted in the first weeks and months, based on only dewatering of the wells, not only proved to be useless, but also spread false expectations and a sense of frustration among users. Activities cannot start to be useful before the first peak of salinity has naturally decreased, but are likely to be effective only after the first rainy season.

How many seasons are required for the water in a well to return to the original aquifer salinity conditions from a water supply point of view is mainly an academic matter.

- Once salinity levels drop below the acceptability threshold (and many wells never exceeded this threshold), wells can be used again, regardless of whether conductivity is still a few hundred units higher than normal.
- The taste acceptability from users proved to be mainly of a psychological nature[7]: in fact, many well-owners have been drinking salty, or highly chlorinated water provided by the bowsers for more than one year, without switching to unsafe sources.
- Bacteriological quality, pollution from agricultural practices, and not salinity, should be the major concern of water quality in the affected wells.

Well rehabilitation should mean well improvement, meaning perhaps less hardware and more correct information regarding the expected evolution of the taste of the water in the wells, and what could be expected from rehabilitation (which could also include a "pro forma" careful dewatering).

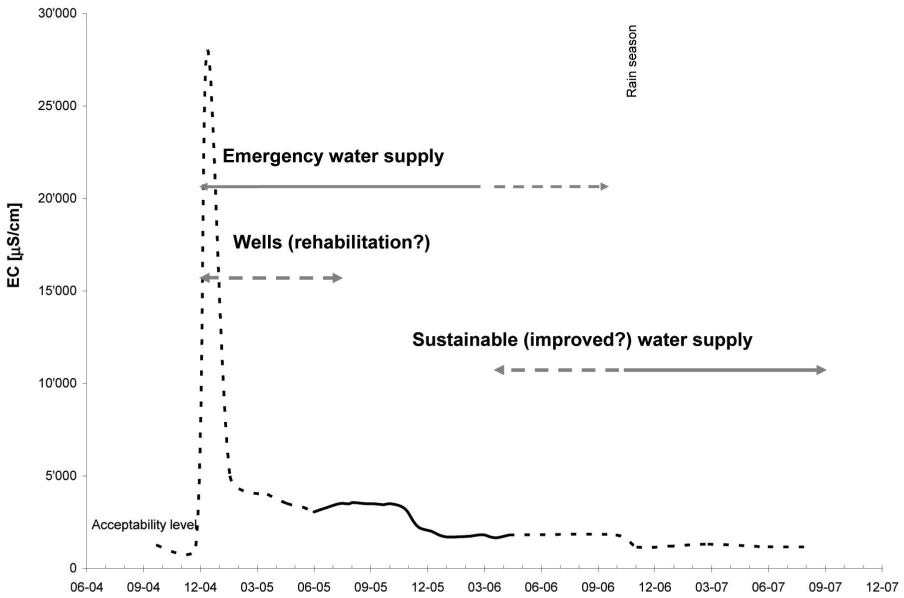

Figure 8. Actual relation between emergency water supply and well rehabilitations vs. salinity variations

Users should be encouraged to protect the wells, and HH purification techniques should be introduced. Restoring well use after the break of the bowsering is also an opportunity to exploit the psychological effects of the tsunami, and achieve a true behavior change.

Box 1 Lesson learned

In case of tsunami, do not try to pump wells to lower salinity, just wait for the rainy season.

Emergency water supply

Emergency water supply, mainly via bowsers, started immediately on a very large scale. Probably it could have been replaced in the medium term by smarter and cheaper systems in more cases than it was, particularly in some TSS. However, given the conditions, it was justified at least until the first rainy season, or just after.[8] It is also worth mentioning that even if bowsering water is by far the most expensive way to provide emergency water, in a context like the tsunami where funds were always largely available, it provided good visibility to the agencies, needed no specific expertise. For this very reason it was sometimes abused, such as when it was conducted in areas where it was not strictly necessary, and included no exit strategy other than suspending the service only when funds eventually ran out. This, in some extreme cases, led to the well-known dependency syndrome, lack of community interest in longer term activities, and certainly can be considered a missed opportunity to drive any improvement in the water supply of the areas where it has been conducted.

Tube wells and hand pumps

The contamination of the shallow coastal aquifers from the existing onsite sanitation systems and the surface has yet to be proved but, given the depth of the aquifer and the sandy nature of the soil, it is very likely to happen.

Thus, it is recommended that water abstracted from shallow tube-wells be disinfected before drinking.

The "Three Tier Maintenance System" has proved to be a failure. It should therefore be revised and customized for those northern and eastern areas affected by on-going violence before new hand pumps are constructed.

Conclusion: constructing back better

"Constructing back better" is the motto of RADA[9] and of the International aid community. In terms of rural water supply, it means not only restoring the pre-tsunami situation (a job managed by nature herself), in which wells were largely contaminated by bacteriological pollution, but also introducing a new water quality awareness and new solutions to the users.

This is not an activity for the first phase of the emergency (Fig. 9): it requires expertise, various kinds of equipment, training of field teams and advocacy to local authorities as well as a clear strategy and good resource planning. It can start as soon as the first wells begin to be usable again, and continue alongside the gradual withdrawal of water distribution. It should be planned alongside the emergency supply as the natural exit strategy as some agencies understood, and can continue in areas not affected by the tsunami , as a development objective.

References

ACF (2006) "Well hand over process" notes to Batticaloa authorities

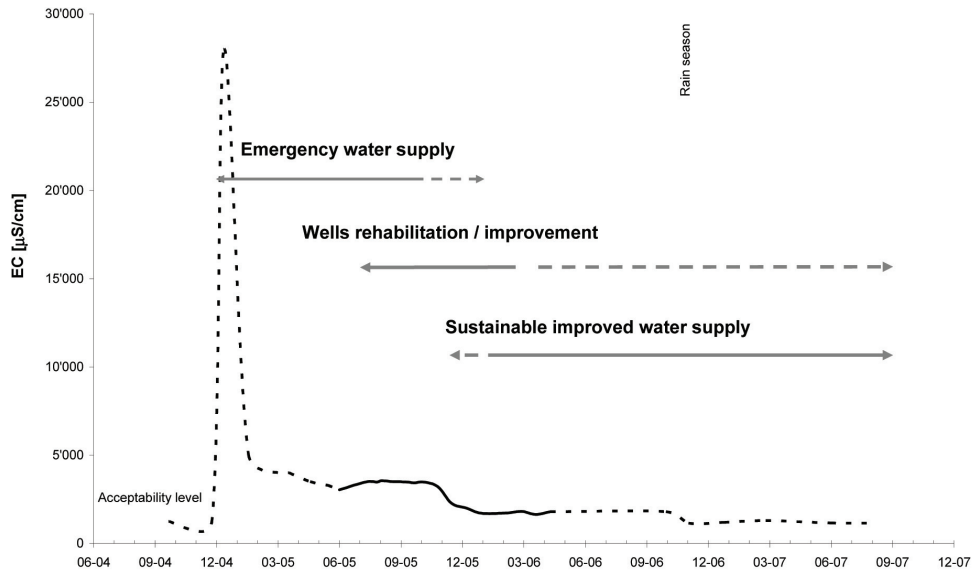

Figure 9. Ideal relation between emergency eater supply and well rehabilitations vs. salinity variations

Box 2 Guidelines for well rehabilitation – UNICEF

- Pumping to clean wells should only be done to remove debris and sludge, and not in an attempt to decrease salinity.
- The less the aquifer is pumped in this phase, the sooner the natural recovery post-tsunami will occur.
- Over-pumping of wells in costal areas can cause infiltration of saline water.
- Wells must not be emptied.
- The practice of emptying wells with strong over pumping, in order to make them accessible for debris cleaning, must be banned.
- Organizations that do not have the proper equipment, or adequately trained personnel, should be discouraged from rehabilitating wells.
- It is not possible to monitor well cleaning or strong well abstraction properly without a conductivity meter.
- Whoever abstracts water from a well in coastal areas with motorized pumps must monitor the salinity of the well on a regular basis.
- If salinity in a well increases, pumping must stop immediately.
- Shock chlorination is an emergency procedure and must be conducted only in case of genuine need.
- Chlorination of wells to purify the water for human consumption is discouraged. Chlorination, or any other suitable water treatment, should be done after water is abstracted from wells, before final consumption.
- Wells intended to provide water for human consumption should be properly sealed. Contamination from surface water and debris must be ensured. Wells for human consumption should meet all the standards of a protected source.
- Whenever possible, rehabilitation of wells should include all works needed to improve the protection of the well.
- Whenever water from an unprotected source has to be used in an emergency, water purification is needed.
- Hygiene promotion and raising awareness on the importance of clean water should be part of any well rehabilitation project.
- Wells must not be deepened in coastal areas in the attempt to reduce salinity, or increase abstraction rates. Hand dug wells with tendency to dry up during the dry season should be deepened up to two metres below the minimum seasonal water level.
- Before proceeding with a rehabilitation campaign, the general situation of the salinity in the area, and the reasonable best possible target for the rehabilitation, should be known.
- It is advisable that organizations involved in well rehabilitation develops internal protocols, to serve as a guideline for the field staff, designed on the base of the present principles, and prepared by specialist technical staff. Adequate training of local field staff is of primary importance.
- Advice can be obtained via the local Water and Sanitation Coordination Groups at District level.

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UNICEF (2005) "Consequences of the Tsunami on the costal aquifer in Eastern Sri Lanka and Wells rehabilitation concepts"

UNICEF (2005) "Overview on Coastal Groundwater Aquifers"

UNICEF (2005) "Guidelines for well rehabilitation"

Villholth, K.G. et alii (2005) "Tsunami Impacts on Shallow Groundwater and Associated Water Supply on the East Coast of Sri Lanka" IWMI

WHO (2003) "Guidelines for Drinking-Water Quality - 3 edition"

Note/s

[1] According to WHO guidelines, the recommended guideline for TDS is 1,000 mg/l (equal to app. 1,453 µS/cm). According to Sri Lanka Standard SLS 614 the acceptability limit is 3,500 µS/cm, and desirable level is 750 µS/cm.

[2] Guidelines value for TDS are not health-based, but are given as advice on acceptability of consumers "although acceptability may vary according to local circumstances" (WHO, 2003)

[3] The "National Water Supply and Drainage Board" manages more than 400 piped water schemes, covering approximately 20% of the population in Sri Lanka.

[4] After the Tsunami, GoSL enforced an existing law according to which no constructions were allowed within 100 m (200 m on the East cost) from the shore. This requirement has since been revised with amendments for specific areas.

[5] Mainly Ampara and Galle

[6] Three Tier Maintenance System put in place by law in 1996, includes three levels: pump caretaker and Consumer Society at the community level, Pradeshya Sabha at the divisional level, and the NWS&DB at the district level.

[7] After the shock of the tsunami, fish was not consumed for months, in the belief that it could have been contaminated by dead bodies

[8] With the exception of the TSS, where it is rightly expected to last the life of the settlement.

[9] Reconstruction And Development Agency, governmental body for the coordination of tsunami-related projects. Since April 2006, RADA merges TAFREN, TAFOR, TAP and THRU, former agencies focusing on specific parts of the relief operations.

Contact addresses

Roberto Saltori, WASH Project Officer - UNICEF
UNICEF Galle e-mail rsaltori@unicef.org, Sri Lanka

Alessandro Giusti, WATHAB coordinator, ICRC
ICRC Colombo - colombo.col@icrc.org, Sri Lanka