



Development of New Landfill Lagoon Side in RMI



Republic of Marshall Islands
Majuro Atoll

KEY WORDS

3R + Return,
CDL

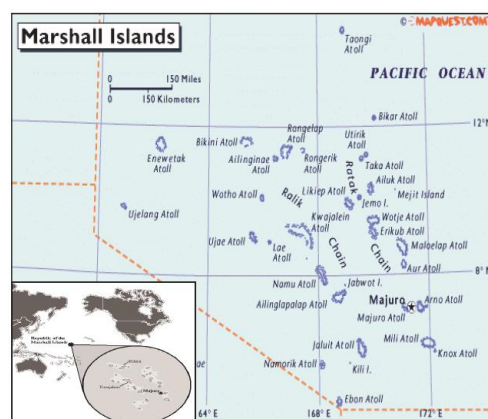
Majuro Atoll holds the capital of the Republic of the Marshall Islands, and is the largest urban area in the country. Being an atoll island, land is only just above sea-level, and no space available for landfill. The existing dumpsite at Batkan village has been in use for over twenty years, and the dumpsite now holds a pile of waste 17 metres high, the highest point in the country, and the situation on the dumpsite is critical. The current situation cannot continue as waste can escape into the ocean from the pile, but there has understandably been resistance to using waste for land reclamation as this might cause pollution of the sea, especially as financial resources are limited. J-PRISM has been assisting the RMI to use waste to create new landfill lagoon-side using natural processes to treat the leachate from the waste. This case study looks at these recent efforts to improve the landfill situation on Majuro.



Leading Agency(s)

The lead agency for managing the Majuro Landfill is the Majuro Atoll Waste Company (MAWC), which is a state-owned enterprise set up in 2007 by the RMI government to collect waste and manage the dumpsite at Batkan on Majuro Atoll. The other lead agencies are the Ministry of Works Infrastructure and Utilities (MWIU), and the Environmental Protection Authority (EPA) of the Republic of the Marshall Islands, which is the regulatory agency for landfills.

Location/ Geographical Coverage



Type of Document

a good practice fact
sheet

Target Audience

Officials of PICs
Donors

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The Marshall Islands comprise 33 atolls located in the central tropical North Pacific, as seen in the map above, from around 4 to 10 degrees north. There are only two urban centers of any size - Majuro and Ebeye - and these hold three quarters of the population, and most consumption and generation of waste takes place in these two locations. Majuro Atoll had around 27,000 inhabitants at the time of the 2011 census, but recent data from the 2021 census indicate a significant fall in population to around 20,000. Majuro is the largest tuna transshipment port in the Pacific, and at any time a number of fishing vessels, and their crew, are also in the lagoon, and generate waste.

An atoll island has two coast types, lagoon-side and ocean-side. Ocean-side sea walls must withstand large wave impacts from ocean breakers, and must be much stronger and more expensive than lagoon-side sea walls, where wave action - depending on location - is usually much weaker.

Measures/Approach

This case study concerns a landfill pilot project for Majuro, using a method for atolls on the lagoon side of the island. The aim is to demonstrate that lagoon-side containment walls can be built at affordable cost, whilst still preventing pollution from the waste to the lagoon waters. The overall method is based the lagoon landfill system used in Tarawa, Kiribati, a neighboring atoll country to the south. The geography of Majuro and Tarawa atolls are similar, except that Tarawa has a shallower lagoon with tidal sand flats, whilst in Majuro the lagoon tends to be deeper.

In the early 2000s, an Asian Development Bank project built two new landfills in Tarawa. These had three walls sitting on the lagoon tidal flat, with the fourth wall comprising the existing land. One landfill runs parallel with a causeway joining two islands, so making that strip of land wider, and the other was behind the main electrical power house. One landfill opened in 2004, whilst the second did not open until 2012. This time lag allowed some comparison to be made on the lagoon water quality between the impacts of the landfill with waste in it, and the similar landfill not yet accepting waste. Comprehensive water tests were taken at both sites in 2012 before the second landfill opened for waste, so allowing a benchmarking of the existing pollution in the lagoon around the site of the landfills. This was essential in order to determine the long-term impact of the landfill operations. The landfill walls were built of a trapezoid section of sand covered on both sides by a concrete skin, as can be seen at Figure 1. The floor of the landfill was lagoon sand, stabilized by mixing with cement.

These water tests showed that the landfill in use seemed to have very little impact on lagoon water quality. It was also seen that the empty landfill held brackish water at a constant mean sea level, apparently unaffected by the

tidal movement in the lagoon. Careful study determined that the water level in the empty landfill did actually move up and down with the tidal cycle, and the lunar cycle, but at about two orders of magnitude less than the tidal movement of the water outside the landfill wall. It was also determined, through careful measurement with water level data loggers, that when a heavy rainfall lifted the landfill water level, it took several days for the level to return to its original equilibrium. These two aspects pointed to a linkage between the water inside and outside of the landfill, but a linkage that was significantly dampened. Discussions amongst various water specialists resulted in the development of a hypothesis that the water was moving between the lagoon and the landfill largely through the sand floor of the landfill. This effect is well known on atolls as shallow freshwater wells provide many houses with water, and the water level in these wells can be observed to move with the tide, especially if near a beach. The lack of water pollution caused by the in-use landfill was hypothesised to be the result of the grains of sand acting as a particle filter, and sand is often used for this function in water treatment systems. Of note also is that Tarawa has no industry, and chemical and hazardous liquid wastes that may be common in developed country landfill are not present. This is a similar situation to Majuro.

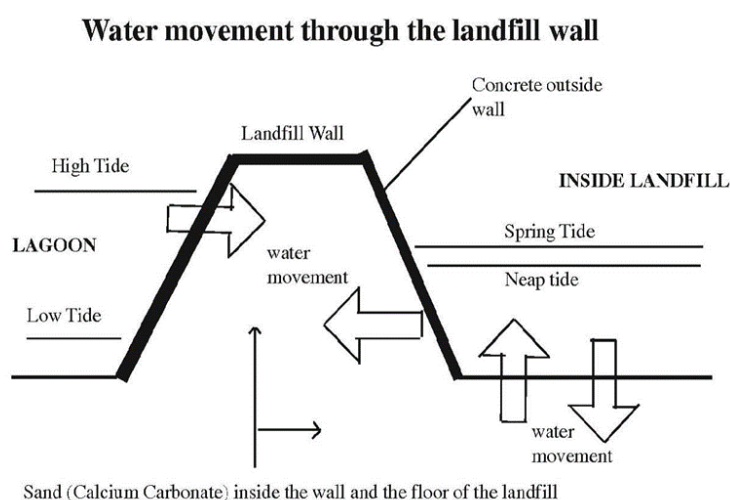


Figure 1: Movement of water through landfill wall

Subsequent to this, the previous work of a Belgian university to use calcium carbonate as part of a leachate treatment system was brought to bear on the issue. Coral sand is almost entirely calcium carbonate as it is composed of tiny bits of dead coral and other animal shells. The European work showed that where a shallow hydraulic gradient can be maintained across the calcium carbonate, and the temperature maintained above 20°C, then conditions are very good for the acidic landfill leachate to be neutralised by

the alkaline coral sand. Understanding this process is crucial to designing the lagoon sea wall. The tide coming and going acts to maintain a varying but simple hydraulic gradient across the sand barrier, slowly allowing rain that collects in the landfill to escape and equilibrium to be restored. But it is essential for this system to work that water movement between waste and lagoon, through a thick sand barrier, is allowed at a low but sufficient rate.

It is essential that rain that falls into the landfill can escape, or else the landfill will fill with water and become boggy, and make heavy machine operation very difficult. If the conventional approach of a landfill liner is used in a landfill below sea level, rain water in the landfill must be pumped out and that water will be polluted, thus requiring treatment ponds on the land before release. The significant land area required for such treatment is typically not available on an atoll; if the leachate is simply pumped into the sea, then it is pointless to put an impermeable liner in the floor of the landfill. As the base of the landfill is below sea level significant pumping effort is required, and this is expensive, requiring continual pumping and electricity for pumps. In addition, if a landfill liner is laid down below sea level, the water pressure from below will tend to lift the liner unless it is heavily weighted down immediately after laying, which of course reduces the volume of waste the cell can accept. All the above mean that it is not realistic to use a liner in an atoll landfill, where the base will inevitably be below mean sea level.

In the light of what was found had worked well in Tarawa, representatives from MAWC, MWIU and EPA visited Tarawa in 2014 with assistance from the SPREP PacWaste project, and were shown the Tarawa landfills. By the time the J-PRISM II project commenced in the RMI, the situation at the landfill site at Batkan had become critical. Piling the waste up higher was getting more and more difficult. MAWC MWIU and EPA consulted with J-PRISM Technical Assistance staff and a plan was drawn up to fill an area on the lagoon-side, across the road from the existing Batkan dumpsite, and test the Tarawa approach in a Majuro setting.

A sea wall into the lagoon has been built across a bay, and two cells have been created behind the wall. Coral sand has been excavated from inside the cells to provide the calcium carbonate material to go behind the sea wall. In addition, sand has been excavated to make the internal cell wall between the two cells, which also provides a roadway to behind the sea wall for construction. Figure 2 shows the two cell layout. By dividing the area into two cells, the filling process is greatly facilitated, and the filling can take place into the cell from the site access gateway from the road, into the

centre of the landfill, along the dividing wall which also acts as an access road. The tipping face then works away from the wall - to the right in figure 2 - and allows steady access into the cell. Great care has to be taken in order to avoid heavy equipment falling into the water in the cell, This is complicated by the fact that much of the waste floats, so it can be harder to see where the solid filled area has reached. Nevertheless, with care and good operators, the tipping face is pushed out, compacting old waste with fresh as it moves, and the trucks bringing in fresh waste also act to assist compaction near the tipping face.



Figure 2: showing Cell 1 at the right, being filled, and Cell 2 at the left, under construction

Stakeholders/Actors

MAWC is the operator of the landfill, and MWIU has taken the lead on developing the design of the containment walls, and contracting out the construction. EPA is responsible as the regulatory agency to monitor the landfill and determine that any pollution found is acceptable and within limits. J-PRISM II technical assistance staff have provided advice and support through the design process, although since February 2020 this support has been remotely provided due to Covid-19 restrictions. The final design of the sea wall was decided by MWIU, and construction has been monitored by the ministry. Funding for construction has come through the RMI government.

Results/Outputs

Working with this lagoon-side landfill has shown MAWC a different way to operate a landfill. The existing Batkan site piles up waste as it has no space, but in the new area, waste is spread and compacted in a more conventional landfill management way. This method gets far more waste into the same space, because the density of the waste is much greater. The other key

aspect of this pilot is to have two cells. One cell can be filled to the level of the main road, and then covered with some sand and left, whilst the second cell is filled. If incoming waste trucks to Cell 2 are then diverted across the first cell, they will add to compaction whilst the second is filled. Once the second cell is filled, after about a year, the tipping face can go back onto the first cell. Some subsidence will have taken place due to the fairly high organic content of the waste stream in Majuro, as this material breaks down much quicker than inorganic waste such as plastics, and so more waste can be packed into Cell 1 later. In addition, if the seawall is built up, the land area can be built up through successive layering of waste, called 'lifts', so that the piece of land ends up higher than the current road, perhaps by around 1-2 metres. Having a high piece of land alongside the road at that point, where the island is very narrow, will help protect the main road from flooding on high tide events.

Success Factors

The ability to build on an existing good model has been a key part of this project. Whilst plans had been in place for several years to build a new landfill in Jenrok, about 10 km away, these had not been fulfilled, and was also budgeted at \$17 million, which was in excess of available funding. The proposed site, which was ocean-side, has subsequently be allocated for a playing field for the next Micronesian Games. J-PRISM provided support to MAWC, MWIU and EPA to develop the proposal for filling lagoon-side at Batkan, with the necessary technical support to help MWIU to design the project in-house.

Challenges/ Constraints

The local community in Majuro has been very wary of formal land-filling at lagoon-side sites, fearing further pollution of a lagoon that is already stressed by a sizable population and fish transshipment operations that regularly see a large number of ocean going fishing boats in the lagoon. This is understandable. Ocean-side landfill has appeared more appealing in that any pollution escaping might be washed into the ocean. But the construction cost of long-term seawalls ocean-side is very high, if they are to be strong enough to withstand the hammering of ocean swells. Thus a concerted effort was made, with the assistance of EPA, to ensure that leading policymakers understood the science behind the lagoon-side wall construction, and how it might protect the lagoon. Another constraint has been that local civil engineers have a certain approach to seawall design, and the design derived from the Tarawa experience to some extent challenges that. For example, sloping external walls are stronger and allow dissipation of wave energy as the waves roll up them, but can be more expensive to build as they use more material per linier meter than vertical walls.

Sustainability

Where good solid landfill is achieved, it can be built up to above surrounding existing land levels, and so provide a long term useful piece of land that may be more resilient to sea level rise. The key is that the containment wall is very thick, with lots of sand between the waste and the concrete wall itself. With a good external wall and sand buttress on the inside, a high degree of compaction of the waste in the landfill can be made. Once then capped off with a covering of a thick layer of sand, this produces good hard ground which can then find a use afterwards. Whilst such land is unsuitable for housing, it can be very useful for industrial types of operations, or for parking of things such as shipping containers - which always take a lot of space - or stockpiles of sand and gravel for construction. Any operation that uses heavy trucks on the site is always good for the first three or so years to help the filled land settle and compact. After that settling period, the land area can be more suitable for a wider range of uses.

Replicability and/or Up-scaling

Building landfills on atolls is extremely challenging due to the problems outlined above: the two key constraints of very little land, and the base of the landfill being below sea level, create major issues around drainage and leachate treatment. Atoll nations are typically small, low income, and do not have resources for complex civil engineering works that would be required where a more conventional landfill approach is taken. The method being tested here has the potential to be repeated elsewhere on a larger landfill. This pilot project can only act short-term to take some pressure off the main Batkan dumpsite, and a new landfill site is desperately needed in Majuro, better placed somewhere away from the urban areas.

The most likely site for a new landfill will be lagoon-side to the west of the airport. Immediately west of the airport and lagoon-side is a semi-industrial area where coral sand is mined and large borrow pits already exist. Past that area to the west, there is a part of the lagoon that is comparatively shallow. A landfill could be built there using the same techniques demonstrated by the Batkan lagoon-side pilot project, where that project can demonstrate that this method does not cause significant lagoon-side pollution. By building a landfill in this area, past the airport, the landfill would be well away from housing, and yet not too far for trucking from the urban area where most waste is generated. In the longer term, a useful piece of land can be built that might find a light industrial use in an area that is already a light industry region of Majuro.

Lessons Learned

The General Manager of MAWC was asked if the new lagoon-side approach had improved operations for MAWC with regard to their landfill operations. He said that "It is much easier for MAWC to tip the waste than to pile it up. Piling up the waste is both inefficient and nor very pleasing to the eye of the public." With regard to the difficulties of filling in a water-filled landfill cell, particularly at the start of operations, MAWC do not report encountering too much difficulty. They report that they layer the waste with sand as an area firms up through compaction, allowing the tipping face to move forward efficiently.

GM Mr. Halston deBrum has this important advice for other atoll nations who might be considering this approach using lagoon-side landfills: "The buy in from relevant stakeholders before any construction happens is very critical. The regulatory, policy makers and landowners must be aware of the project and its benefits to the community. There has been questions raised in the parliament thru the national radio about the project and its potential effects it may have on the marine life on the lagoon side. I believe that continuous explanation of the project is needed and not just a one-off meeting." The ongoing monitoring of the lagoon through regular water tests is an important part of ensuring support from the community as it will show if there are any actual pollution problems occurring.

Regarding equipment that MAWC has used as part of the landfilling, they believe that a bulldozer would make filling more efficient, as currently they have to use an excavator. MAWC are seeking funding for a bulldozer.

Mr. deBrum adds that "MAWC is very grateful for the technical assistance and monitoring that the JPRISM has done during this project. The management team here is able to present to the decision makers the sound reasoning behind the lagoon side landfill extension, through simple interpretation done by the JPRISM team."

Conclusion

This project will show two things: that lagoon-side landfilling can be done without major pollution impacts, as seen in Kiribati. Also, the technique of landfilling with cells, layering and compaction is being used whereas the existing Batkan pile used a different approach of uncompacted waste that is just piled up. Overall, the waste can be used to build new land, and raise land levels, that after capping off with suitable cover layers, can provide land that can be used for purposes other than housing, such as playing fields, shipping container parks, light industrial buildings, a materials recovery facility for recycling, etc, so releasing good clean land for other uses such as housing.



Contributions to SDGs

- Goal 11: Sustainable cities and communities
- Goal 12: Responsible consumption and production

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Publisher

J-PRISM: The Project for Promotion of Regional Initiative Solid Waste Management, JICA: Japan International Cooperation Agency

Relevant Websites/Resources

Acknowledgments

- SPREP: Secretariat of the Pacific Regional Environmental Programme
- Environmental Protection Agency, the Marshall Islands
- Majuro Atoll Waste Company, the Marshall Islands