APPROPRIATE TECHNOLOGY
FOR
REMOTE COMMUNITIES

A selection of papers illustrating
the effort carried out by the
Remote Area Developments Group
Murdoch University

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FOREWORD

Environmental health conditions in remote communities can be significantly improved by the provision of technology in water, sanitation and related areas. The technology has, however, to recognise the particular settings of remote communities and in Australia this means long distances to supplies for spare parts and to service centres, harsh climates, limited water and lack of human and physical resources.

The Remote Area Developments Group (RADG) of the Institute for Environmental Science at Murdoch University has researched and developed technologies appropriate to such conditions utilising renewable energy whenever possible and taking into account cultural factors of Aboriginal people, involving consultation and feedback. The technologies are of course appropriate to remote areas in general, such as mining camps and pastoral stations.

This publication is an attempt to summarize current efforts by RADG. The appropriateness of an ablution block (Remote Area Hygiene Facility) is discussed with reference to our major objective of involving community members in its construction and eventually maintenance. Specific technologies associated with the hygiene facility (solar water heater, evapotranspiration wastewater disposal, solar lighting and options for water supply desalination) are then described. Growing plants, revegetation, bacterial testing of water for drinking, composting of organic waste and communication in remote areas are an integral part of environmental health. Efforts in these areas are outlined.

RADG is cooperating very closely with the Remote Area Technology Centre at Pundulmurra College, South Hedland. The Centre is manufacturing technologies developed by the Group and through it we will obtain feedback that can be used to develop further technologies. Similarly we have a similar arrangement with Ninga Mia Aboriginal Corporation in Kalgoorlie. This is part of a longer term goal of developing Aboriginal enterprise discussed in the last paper.

We wish to acknowledge the assistance of many people who have expressed to us needs and problems in remote areas, thus providing a focus for our technological efforts, and we express our appreciation to government agencies and funding bodies which have provided the necessary funding to achieve our objectives of servicing communities in remote areas. These include the Aboriginal Affairs Planning Authority, Water Authority and Health Department of Western Australia, Aboriginal and Torres Straits Islanders Commission, National Health and Medical Research Council - Public Health Research & Development Committee, Land and Water Resources Research and Development Corporation, Australian National Parks and Wildlife Service and Greening Australia.

I would like to acknowledge the tremendous efforts of Dr. Kuruvilla Mathew, Research Fellow and Coordinator of RADG and members of the Group. A brief history and current members of the Group is given in the back cover.

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THE DEVELOPMENT OF THE REMOTE AREA HYGIENE FACILITY FOR REMOTE COMMUNITIES - APPROPRIATE TECHNOLOGY?

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The Remote Area Hygiene Facility is being developed as an appropriate technology solution to hygiene problems in remote communities. This paper gives a run down on the process and design involved, and considers the issue of 'appropriateness' for Aboriginal communities in terms of consultation with and acceptance by the people and the need for a flexible modular design.

INTRODUCTION

The Remote Area Hygiene Facility (RAHF) is an attempt at an ablution block design and essentially comprises laundry, toilet and shower. The development of this ablutions facility has not been without criticism. It follows on from the design offered by the Centre for Appropriate Technology - the ATAF. A sketch of the original design is shown in figure 1.

TOILET

The toilet as proposed is a pour-flush type having its origin in Pacific Islands and India. It uses a concrete seat from a mould into which a plastic pan with a U-bend is inserted. A spring-loaded tap with a 2.5 litre bucket is provided in the compartment for flushing by hand. A length of rubber hose is bolted to the wall so that if nappies, T-shirts or newspaper, block the bend they can be forced straight through whereupon they will fall directly into the pit below. The pit is first dug to 800 mm depth, then a corrugated iron liner is dropped in with concrete poured around the outside. The pit is then dug out to 2300 mm. This pit design avoids costly transportation and handling of a cumbersome, fragile septic tank to a remote location. The U-bend provides a water seal and eliminates odours and flies. It is a compromise between a pit toilet and a cistern-flush ceramic toilet and is intended to avoid S-bend and T-piece blockages, minimise water consumption and avoid the need for comprehensive sewerage.

HOT WATER SYSTEM

The solar water heater is a low pressure plastic unit aimed at avoiding corrosion, blockages, rupture due to freezing, smashed glazing with an ability to be assembled in a low technology workshop and transported to site or overseas in a compact, collapsed form. The Solco (or SunSaver) solar water heater is a commercially available unit at a very low price of around $800 but is made from polyethylene which has maximum temperature limit of 90 degrees Celsius and would probably melt if left without water or inadvertently drained in the sun. The cheapest
commercial metallic unit in W.A. is by Small with a two year guarantee at about $1200. The RADG solar water heater currently costs $1500 in components and can only be considered as a prototype for development at this stage. A high temperature, high pressure unit is also under development by RADG.

The hot water system also includes a chip heater as originally designed by the Centre for Appropriate Technology. It is made from condemned LPG cylinders and is fired up in overcast or cold weather when many users render the solar water heater inadequate.

WASTEWATER DISPOSAL

Waste water disposal from shower, laundry and toilet pit overflow is by evapotranspiration trench which is superior in performance to leach drains in tight clayey soils and relies on and facilitates the growth of the trees.

A hand operated washing machine designed by CAT is provided.

CONSTRUCTION

The wall and roof panel are made from 50 x 50 x 2.5 mm steel tube in 2 metre x 2 metre modules on a jig for ease of transport and assembly. Of course this construction is very robust. Walls are clad in Panel Rib colourbond metal sheet. Roofing is custom orb. Slab form work is by C-purlins with locating studs welded on, onto which the wall frames are tek screwed once the concrete is set. The slab should be set at the correct gradient so that water flows towards the spoon drain in the middle from whence it flows into the ET trench via a specially moulded drainbox and soakwell.

The RAHF can be transported to site as a prefabricated kit requiring 'excavations, concreting, steelwork assembly and plumbing on site. It will cost roughly $18,000 while other ablution blocks are in the range of $20,000 to $60,000.

EXISTING PROGRAMS OF CONSTRUCTION

Kalgoorlie

Four of these were built at Kalgoorlie as a community based construction training/employment project during December 1990 to June 1991. The end users were the Pepper Tree Camp fringe dwellers. A video was produced based on this project describing the method of construction and community involvement (Anda, 1991). Three town Aboriginal/Islanders and three fringe dwellers worked on construction. These people were previously alcoholics and semi-skilled and in the end could quite competently and independently finish the Remote Area Hygiene Facility.

Two 'Solco' solar water heaters were used on two RAHFS and the polycarbonate glazing was smashed by rocks defeating the purpose of this exorbitant expense. Water temperature was not hot in July. At this coldest time of the year the RADG unit was
operating satisfactorily but only luke warm and required the support of the chipheater. The shower roses needed to be relocated directly overhead due to the low pressure. It is also very difficult to find a robust shower rose.

Effluent disposal in the ET trench after 6 months and at this cold time of the year was satisfactory. Being cold there is less evaporation and also at this time there were not any trees yet.

The materials of construction had survived quite happily the rugged lifestyle in this camp.

A problem arose with the pour-flush toilet.

Due to unsatisfactory cleaning by the residents, Preston Thomas, the co-ordinator of Ninga Mia Village and the project, had assigned Ray to hose out the ablution blocks each morning.

Ray found that the U-bend was restricting flushing and his cleaning efforts so promptly disconnected them perhaps not realising that the toilet had now lost its water seal and had effectively become a pit toilet. As far as could be understood and on an earlier visit the residents had been flushing the toilet before Ray took the initiatives. In fairness to Ray, the cleaning of the toilet before hand by Gwen, a camp resident, had been an arduous task due to lack of attention by the numerous intoxicated users.

Preston had pointed out the need for lighting in the camp which was without electrical power. RADG commenced investigation into available solar lights and found that none would be completely reliable for this application and have initiated development of a unit in collaboration with Murdoch University Energy Research Institute (MUREI) and Northern Building Consultants. The solar light should be ready for trials in 6 months.

Halls Creek

As with the Kalgoorlie project the Aboriginal Affairs Planning Authority (AAPA) funded RADG to co-ordinate the construction of initially one RAHF and later another 10 at Mardiwa Loop fringe dwellers camp in Halls Creek. The first was built in January 1991 and ten were started 4 months later. The first was constructed quickly and happily by Colin Beck, an Aboriginal builder in Hedland with 3 residents. The solar water heater was not installed until 3 months later at the fault of this author due to remoteness, resulting in no hot water until that time. It was intended to construct the 10 in much the same way until TAFE decided to step in and take over on-site management of the project. There have been considerable delays since then. The training expertise offered by TAFE may be an advantage but it may be a case of too many chiefs and not enough workers. The Remote Area Technology Centre was able to prefabricate 5 RAHF's for Halls Creek involving a number of Aboriginal trainee/employees. These were trucked to the site one at a time. A convenient packaging system soon became apparent and enquiries have been received from CALM national parks and
Indonesia. The second five would be fabricated completely on site by Ngunjwah Council, Mardiwa Loop and TAFE. RADG could always be available for technical support and development.

Upon completion of the first RAHF a number of Mardiwa Loop people were asked to offer their opinions on the features of the ablutions block. Charlie Yeeda and others at several times had indicated their dissatisfaction with the method of toilet flushing and would have preferred the modern flushing type.

I advised that later the toilets could be converted to a cistern type flush model. This experience and Kalgoorlie motivated RADG to develop a new type of cistern that would be more robust and reliable and still only require the use of 3 litres of water. It would connect into the rear of the toilet seat and may require upgrading to a stainless steel pan to facilitate installation of a fluted discharge nozzle. This would force the water directly downwards as opposed to the swirling and suction effect of a standard S-bend toilet pan.

After the first unit had been operating for 4 months the community decided it would prefer the toilet and shower separated to avoid embarrassment during simultaneous use. The first four had already been prefabricated at Pundulmurra College but the design will be revised on subsequent units so that shower and toilet are located at opposite ends with the laundry in the middle.

An inspection by the Kimberley Environmental Health Worker Supervisor led to advice that the toilet should be internally lined with wall cladding to enable improved cleanliness. The wall cavity should be filled with fibreglass insulation to prevent cockroach breeding. This will also act as noise and heat suppression. The edges of the concrete slab should be coved to allow ease of cleaning and retention of water within the drainage.

Architect Mile Ipkendanz (Ardeco Australia) inspected the unit and offered his advice. 'The toilet should be separate and not part of the ablutions block'. The 50 x 50 tube should be replaced by 35 x 35 x 1.5 mm if using a MIG welding machine in the workshop with an experienced welder. When using the new BHP Steel tube 'Duragalv' a vacuum suction/exhaust should be fitted to the MIG welding nozzle. The fumes emanating from the galvanised coating upon combustion are carcinogenic. The use of a hole saw for passage of copper piping through wall frames would reduce all the work of cutting and welding in channels. The roof should have overhang for wall shading resulting in lower internal temperatures. The use of more bolted joints could be considered for more on-site assembly.

Architect Kim Coleman also inspected the unit for possible application on Kimberley out stations. He felt the unit was too expensive. The solar water heater was not necessary and should be replaced by a singular sloping roof with overhang for shade supported by a C-purlin beam. The 50 x 50 frame construction was too heavy and could be replaced by lightweight galvanised channel.
A solar water heater may not be as necessary in the tropical Kimberley but it is useful in the semi-arid Pilbara and Central Desert where you have cold night temperatures and high solar radiation.

CONCLUSION

Each of these design variations can be considered in the light of each community application. The nature of appropriate technology is a community based exercise with community involvement. To some extent when using new technologies that can possibly provide advantages over conventional technologies one needs to be careful not to be condescending and make sure that the background behind the 'felt' needs of the client are investigated and understood.

A 'how-to-build' design manual has been produced with step-by-step photographs, materials lists, suppliers, and clear construction drawings. This is upgraded with each improvement or modification.

A new RAHF design will be produced as a result of these experiences in the spirit of a consultative developmental approach to the provision of infrastructure in Aboriginal communities.

ACKNOWLEDGEMENTS

The research and development of the RAHF was made possible with funding from the Aboriginal Affairs Planning Authority and the National Health and Medical Research Council.
A SOLAR WATER HEATER FOR REMOTE COMMUNITIES

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Conventional solar hot water systems do not usually perform well in remote arid environments in Australia, including remote Aboriginal communities. A simple hot water system made from plastic materials that can be assembled in kit form and therefore can be repaired in the field is described. The principles for designing the system and the testing of a prototype is reported.

INTRODUCTION

The RADG has been developing a solar water heater suitable for use in remote areas. The original inspiration for this project was to provide hot water for remote Aboriginal communities. It was felt that a regular and plentiful supply of hot water would encourage showering and laundering and hence improve personal hygiene.

Electric, fuel burning and solar water heaters are currently used in some communities. Solar water heaters are attractive for remote areas because they stand alone i.e. they require no external fuel source. Wood has traditionally been used as a fuel by Aboriginal people, but in permanent communities the demand on this resource may have a large impact on the environment. Solar water heaters can help to reduce this demand.

CONVENTIONAL SYSTEMS

Conventional solar water heaters used in remote communities are subject to the following problems (Walker 1984):
- freezing causes fracture of the copper tubes;
- servicing of cracked tubes or other failed components is not readily available within communities;
- glazing is smashed by rocks;
- absence of electricity to boost supply on overcast days;
- Aboriginal people find difficulty relating to that technology in a meaningful way;
- the quality of water in remote areas leads to a rapid build-up of deposits in the copper tubes, resisting flow or causing complete blockage;
- the volume of hot water generated is sometimes insufficient for a given usage pattern;
- contractors have sometimes installed the equipment incorrectly.

Some of these problems can be solved by modifying conventional solar heaters. With an indirect system, draw off water only passes through a heat exchanger placed in the storage tank. The closed collector/tank loop can be filled with clean water plus anti-freeze and anti-corrosion additives. Alternatively, scaling
can be reduced by fitting galvanic or magnetic filters. Both of these solutions add to the cost and complexity of the system.

THE RADG SOLAR WATER HEATER

The aim of the RADG in developing a solar water heater was to overcome the problems of conventional systems in a simple and cost-effective way. To this end various prototypes were built (Anda 1988) largely using plastic materials.

Plastics are attractive in this application because they are cheap, lightweight, easy to work with and generally more resistant to corrosion, scaling and freezing than metals are. Limitations in using plastics include long term weatherability, mechanical properties at elevated temperatures and the range of plastic products and forming processes available in W.A.

The latest prototype is a low pressure, semi-glazed, thermosyphon system. The absorber of this prototype is made from an extruded ethylene-propylene-diene-monomer section (manufactured for swimming pool heating) mechanically joined to cPVC header manifolds. Glazing is in the form of clip on acrylic panels and collector insulation is polystyrene foam. The storage tank consists of a 180 litre polyethylene tank insulated with polyethylene and polystyrene foam encased in a metal jacket. A float valve reduces the water pressure to a low level.

All of the materials used in the construction of this system are relatively less expensive and readily available. The system is supplied in kit form to be constructed on site by community members. This should enable communities to maintain the system and repair it if it breaks down.

These systems are currently being built at the Remote Area Technology Centre in Pundulmarra College (Port Hedland) and are supplied with the Remote Area Hygiene Facility developed by the RADG. A chip heater developed at the Centre for Appropriate Technology (Alice Springs) is used in conjunction with the solar heater to assure a year round supply of hot water.

TESTING

Several prototypes have been developed and tested by the group in different parts of W.A.. Testing of an earlier unglazed prototype made from Solar Batts (manufactured for pool heating) has been carried out in Perth and Newman (Anda 1988). Final tank temperatures reached in September were typically 40'C in Perth and 50'C in Newman. Testing of the latest prototype will be conducted at Murdoch University.

FUTURE DEVELOPMENTS

Research is now being conducted into developing a class A solar water heater for remote areas. Class A is a mode of operation in which the water delivery temperature at the hot outlet remains above 57'C under a specified load condition (AS2984 1984). Design for operation at mains pressure will also be considered.
The reasons for developing a high temperature/pressure system are:
- the risk of Legionella contamination in potable hot water stored below 55°C (O'Connor 1989);
- the low rate of water flow from shower heads;
- Aboriginal peoples may desire an urban type system.

To produce water at high temperatures during periods of low ambient air temperature and radiation requires a well insulated collector (i.e. fully glazed). However, during prolonged periods of high temperature and radiation, a well insulated collector may reach very high temperatures (up to 150°C) under thermal stagnation conditions.

Plastics capable of operating at such high temperatures include fluoroplastics, polysulphones and polyamides (Birley et al 1988). These plastics are generally expensive and not readily available in W.A.. For these reasons a high temperature safety device is being considered to restrict the collector temperature to under 100°C. This device may be along the lines of variable glazing or venting. Restricting the temperature to this level will allow a much wider range of plastics to be used including high density polyethylene, polypropylene, polycarbonate, polybutylene, glass reinforced polyester and EPDM (Madsen & Goss 1981, Lenel & Mudd 1984). Many of these plastics are cheap and readily available in W.A..

Apart from high temperature, the materials must also be able to withstand mechanical stress (due to high water pressure), UV radiation, water, oxidation and weathering.

Suitable plastics and forming processes are currently being assessed with the aim of building and testing a high temperature/pressure prototype in the near future.

CONCLUSIONS

The RADG has developed a durable plastic solar water heater for remote communities. It is easy to transport and can be constructed on site by community members.

Testing of earlier prototypes has shown that good performance can be achieved using plastic materials. Development of a high temperature/pressure system is currently underway.
REFERENCES


EVAPOTRANSPIRATION SYSTEMS AT IRRUNGADGI COMMUNITY, NULLAGINE: A CASE STUDY

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Details of trial installation of evapotranspiration trenches in Nullagine community, in the western Pilbara area are outlined. The installation of trenches involves planting, maintenance and monitoring work.

INTRODUCTION

The failure of conventional septic tank/leach drain systems in Aboriginal communities arises commonly from factors such as excessive water use and impermeable soils (such as those with clay or bedrock), in which the rate of movement of effluent away from the disposal field is less than the rate of wastewater generation, inevitably resulting in failure of the drain (McGrath et al 1990). When this occurs, the general policy of the Western Australian Water Authority has been to install reticulated sewerage, which can be very expensive ($300 000 - $500 000 for a community of ten houses) (K. Mathew 1990, personal communication).

To overcome this problem more economically, the Remote Area Developments Group has been investigating the use of Evapotranspiration (ET) systems. An ET system is comprised of a shallow trench or bed partially filled with gravel above which a sand layer is placed. A thin layer of top soil (5cm depth) is placed above this capillary layer. Wastewater flowing into the system is taken up by plants growing on the trench and by evaporation from the surface of the trench (McGrath et al 1990).

Irrungadgi community is a small fringedweller settlement situated on the outskirts of Nullagine, some 200km north of Newman. The community is comprised of nine houses with separate ablution facilities. As part of an upgrading programme for the community, a wet area was added on to each of the houses, comprising a shower, flushing toilet and laundry area. Wastewater from the houses was disposed of in leach drains for five houses. Two houses were installed with Evapotranspiration (ET) systems to dispose of household effluent. The ET systems were installed in May 1991 and planting took place in July 1991.

This report briefly outlines the installation of and planting of the ET systems at Irrungadgi, the problems encountered and those likely to be encountered in system functioning and monitoring.

SYSTEM DESIGN

Each ET system was initially designed using the water balance method detailed in McGrath (1989) to service a household of 15 people and was 45m² in area and with a depth of 1m. The trench was filled with 50cm of graded gravel above which a 50cm layer of river sand was placed (Figure 1) A top soil layer was not used as this was shown to decrease evaporation rates from the trench (Perkins 1989). The gravel layer 's purpose was to
Figure 1: Evapotranspiration Systems at Irrungadgi Community

Figure 1a: System 1
- 1.8m
- 10cm sand
- crushed rock
- precast concrete soakwell (1200mm diameter, 1.5m tall)
- river sand
- graded gravel
- standpipe

Figure 1b: System 2
- Septic tanks
- 10cm sand
- river sand
- brick soakwell (constructed on-site, 1m wide, 1m long, 0.9m deep)
- graded gravel
- standpipe
- river sand
- graded gravel
provide wastewater storage and act as a distributor of the effluent throughout the system.

Upon arriving at Irrungadgi however, it was observed that the leach drains being installed were comprised of two 11m long drains with a width of 1.3m. This factor, coupled with the observation that people did not appear to be using as much water as was previously estimated in calculating ET system sizing, resulted in decreasing the area of one of the trenches to correspond to the surface area of the leach drains (22m long and 1.3m wide). In this way a more direct comparison could be made between the effectiveness of ET systems and leach drains in disposing of wastewater.

In both of the systems installed, three standpipes were positioned at intervals along the trench to allow water levels to be monitored in the disposal field.

System 1

System 1 was excavated as a trench 22m long and 1.3m wide and for the most part, 1m deep. A fall of 100mm had been provided in digging the trench to allow gravity movement of wastewater towards the end of the trench to occur. The concrete soakwell used was considerably larger than anticipated, being 1.5m in height. The first couple of metres of trench was hence dug to a depth of 1.6m to allow soakwell installation. The soakwell was placed directly onto the base of the trench without a layer of gravel being added first. The area directly around the soakwell however, was filled in with rocks and gravel as was directed by the original design.

The base of the trench was filled with a 20cm layer of crushed rock above which the distribution pipe was placed. The pipe had been slotted to allow wastewater distribution to occur in the gravel layer. A further 30cm of graded gravel was then laid in the trench. Two standpipes had been inserted into the distribution pipe to provide an opportunity to take wastewater samples from the system if needed (figure 1a). A third standpipe was positioned some two metres from the end of the trench to provide an opportunity to measure water levels in the system.

System 2

System 2 was constructed as detailed in Figure 1b. A layer of gravel however, was not laid beneath the soakwell as initially planned; river sand was used instead. This was because the builders needed a firm foundation to build the soakwell on which would not have been provided if gravel had been used. The brick soakwell was constructed to the dimensions detailed, with gaps of 1-3cm being provided between each brick. The bricks used were roughly 30x6x5cm in size and did not have any holes. Each brick was cemented into position. A concrete lid was cast and placed on top of the soakwell which was then covered with a 10cm layer of sand.

The reasons for the differences in construction materials of the ET systems was primarily to test the effectiveness of different soakwell construction (which type will/won't block or if both
are suitable) and if the gravel layer is sufficient to provide distribution of effluent without added piping. Day (1982) and McGrath (1989) observed that effluent was distributed evenly in the gravel layer without using distribution piping.

Fill Material

The gravel used in the systems had to be graded to prevent the top sand layer from sinking into the gravel voids. Three sizes of crushed rock was used in the trench. The rock was appropriated from piles of tailings from mining operations. The bottom 20cm of trench was filled with rocks ranging in size from 4-15cm above which a 10cm layer of rock of 2-6cm in diameter was placed. Another 10cm layer of smaller gravel (roughly 1-3cm in diameter) was laid on top of this. River sand taken from a nearby creek bed was placed above the gravel layers. The sand was a mixture of silty sand and small pea gravel with some larger stones occasionally interspersed.

Piping

PVC piping was used to connect the septic tank wastewater outlet to the soakwell in each trench. In both systems the soakwell was positioned 1.8m from the second septic tank, leaving a gap between the well and the start of the trench of some 80cm. The short length of pipe between the trench and the septic tank ensures that any blockages that occur can be easily cleaned (McGrath et al 1990).

Piping from the ablutions block to the first septic tank, between the two septic tanks and from the second septic tank to the soakwell were all sealed and made watertight using concrete. Because this prevented leakages it was unlikely that any plants grown on the systems would damage these structures due to roots seeking water and growing into cracks.

PLANTING E.T. SYSTEMS AT NULLAGINE

Plants obtained from Pundulmurra nursery were planted on either side of each of the two trenches constructed at Nullagine. The species used were Acacia ampliceps, A. ligulata, A. craspedocarpa, A. aneura and E. camaldulensis. McGlew (1990 personal communication) noted that these species would be suitable for the conditions occurring in ET systems. Other species for establishment on the trench surface are currently being grown by Pundulmurra nursery and will be planted at a later date. Approximately 50 plants were planted for each trench with drip feed irrigation systems also being installed.

Irrigation Systems

The irrigation system was comprised of a 44 gallon drum to which was connected a 20m length of 13mm polyethylene piping. Ten drip outlets were spaced out at regular intervals along the piping, each outlet consisting of a 20cm length of 5mm polyethylene piping upon which was attached a dripper (4L/hr). Previous testing of the equipment at Murdoch University showed that when on a slight slope, the volume of water coming from each outlet was similar with no significant drop in volume
output at the furthest outlet. This equipment (drum + piping) was installed on both sides of each trench (Figure 2).

To allow root watering of the plants, a 50cm long slotted PVC pipe was positioned in the ground at each outlet. CALM (1990) stated that shallow light surface watering of plants encouraged shallow root growth rather than the establishment of a deep water-seeking network of roots. The dripper was hence inserted into the pipe which was then filled up with gravel to prevent children filling the pipes with unsuitable material that might block the irrigation system. Two to three plants were then planted around each PVC pipe. All irrigation piping was buried 5-10cm beneath the ground (Figure 3).

To get community participation in this project the Nullagine school was approached. It was thought that if the children were given some part in the exercise and felt responsible for the welfare of the plants the vegetation may have a chance of becoming established. Children from Nullagine Primary School hence came and helped in planting on one of the trenches. The young people that participated were among those that lived at the community. Some showed considerable interest in what was being done.

E.T. SYSTEM MAINTENANCE

The only maintenance that should be required on the ET systems in the first year or so is watering of plants. Providing they are not pulled out or otherwise interfered with, watering would be needed for at least six months. A member of the local council responded positively to the suggestion of filling the drums with water at weekly intervals. This would ensure that each plant was receiving about 10L of water each week, which should be sufficient for survival.

MONITORING OF E.T. SYSTEM

Bob Newman, the Health Surveyor for the East Pilbara, has indicated his willingness to take water level readings from the trenches at monthly intervals. The water usage of individual households and the community in general would also be recorded so that an estimate can be made of the water entering the ET systems. This would provide significant data on community water consumption that has not been collected in the past (Holbrook 1990, personal communication). A week or so may be spent at the community at a later date to get other data such as soil moisture, water usage, temperature, humidity and so on. Once the plants are established, water usage measurements will also be taken using the heat balance method, the equipment for which will be borrowed from Horticultural science at Murdoch University.

POTENTIAL PROBLEMS

One of the major problems in getting any results from the work at Nullagine is that there may very well not be enough wastewater generated to really test the effectiveness of the system and to water the vegetation planted on and adjacent to the disposal field. It was apparent from visits to the community that household water usage was considerably lower than
anticipated. There are also some doubts as to whether these plants will survive long enough to become established. The weather was good for planting in that Nullagine had a considerable amount of rain during July (the month of planting); however the people at the community may kill the plants by driving on them, children ripping them up and so on.

REFERENCES


SOLAR LIGHTING

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After designing the Remote Area Hygiene Facility which has been installed in various communities, RADG has received requests to improve on the design. One such request is for lighting for night time use in remote areas, where street lighting may not exist. This paper describes how this is achieved.

INTRODUCTION

The project was initiated following a request from the Ninga Mia Corporation at Kalgoorlie, who wanted simple and inexpensive solar lighting for their ablution blocks. It was decided to purchase various components from solar energy retailers and assess the most cost effective combination for limited range of applications. The priority was placed on a single light installation for ablution blocks and street lighting, and a two light system for ablution blocks with toilet and laundry facilities.

SYSTEM DESIGN

Essential components of the solar light system are
1. Solar panel
2. Battery bank
3. Light
4. Night switch
5. Battery protection
6. Regulator

Solar panel

These are available in a range of sizes from very small to 60W and will cost about $10 per rated watt.

Battery bank

The battery chosen for initial tests was the Century Deep Discharge 55 Ah but can be provided in a range of both wattage and voltage. Deep discharge batteries are essential for the solar light as they are the only ones capable of operating on a charge discharge cycle rather than a floating cycle used in cars or Telecom facilities. Nickel-Cadmium (NiCad) batteries will be considered but they are more expensive and don't last as long. Maintenance free gel batteries are not suited to deep cycling and will give only a short life under these conditions. They may, however be suitable if only shallow cycling is permitted. Low maintenance lead acid are the best option at the moment and they can be supplied in configurations which make them difficult to use in vehicles. For really long life in solar installations, 6V large capacity batteries are recommended.
Lights

Since the greatest brightness per watt is the main criteria for lights, the choice is between fluorescent and quartz-halogen (QH) were chosen as they have a long life and can be accommodated in sturdy bunker housings. I have not seen a comparison between the lighting efficiency of QH compared to fluoro lights but I suspect they would be similar.

Night Switch

The purpose of the night switch is to turn the light on at night and keep it off during the day so that no power is wasted. Two types are possible. One can use a light sensitive diode or similar device to sense nighttime, the other senses when the solar panel is not producing electricity and thus assumes it is nighttime. Either method is suitable and the latter was supplied at a cost of $115.

Battery protection

A low voltage cut-out is designed to shut the light off when the battery voltage has dropped to a predetermined level. A battery will last twice as long if only cycled 30% compared to 50%, so we need to switch the light off when the battery has discharged down to about three quarters of its initial charge. The fully charged voltage of a new battery is about 14V and a 25% discharge would take it down to about 12.5V. As the battery ages however the fully charged voltage drops and so will tend to approach the shut-off level. However, if the battery protection system does enhance the life of the battery, this may take 2-3 years, so a shut-off voltage of 12V or so seems reasonable.

Regulation

A regulator's function is to prevent the solar panel from overcharging the battery and boiling it dry, so it must shut down the power from the panel when it senses that the battery is fully charged. At the same time it must float the incoming voltage around this point so that the battery just boils occasionally. This prevents stratification and sulfonation inside the battery which would shorten its useful life. It is not possible to use a standard regulator with the night switch we bought but the night switch has a form of regulation in it in that it switches the load back on when the battery reaches 15V, thereby shedding some power. If the battery is fully charged by say 3.00 pm, and the panel is still producing 3 amps, the switch will turn the light on and shed 1 amp leaving 2 amps to boil the battery for an hour or so until it drops down as the sun drops. In this case, two lights would be a better option but it is obvious that the system must be much more carefully designed than one with a standard and forgiving regulator. By the same token, it reduces the cost and complexity of the unit as a whole.
The need to carefully design the system has forced us to look carefully at the charge/discharge capacity of the unit and model it on computer. From the modelling we designed the following systems.

A simple single light unit, cycled 25% and with no carry-over for subsequent days could produce an average of 16 hours of light from one 35W panel and a 55Ah battery.

A two light system could produce 8 hours of light from a 35W panel.

COST

The unit should cost about $700 for a two light system which compares very favourably with other units on the market. This price does not include labour or profit so a realistic price supplied to communities would be around $1000.

TESTING PROGRAM

A test unit was constructed but poor weather has prevented any detailed testing. Testing has recommenced with the onset of favourable weather.

RECOMMENDATIONS

We now favour of replacing the night switch with a light sensitive diode and using standard regulation. The low voltage cut-out we have made is not an off-the-shelf item so is not really suited to community development projects or decentralised production. Advanced Energy Systems market a low voltage cut-out that should be investigated if production of the solar light assembly is to proceed, then all the components could be purchased separately and just assembled in a workshop. Their cut-out also flashes the light prior to turning it off, so it gives people a chance to pack up belongings and retire in good time.
SOLAR DESALINATION

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Solar powered reverse osmosis can provide source of potable water that is cheap enough for small communities. The use of alternative energy is also an advance, especially for a technology that must function far from sources of fuel. This paper describes a prototype solar power reverse osmosis unit and its operation and testing.

INTRODUCTION

Many inland community water sources have salinities in the range of 3000-6000 ppm, making it unsuitable for drinking water supply. Nitrate and fluoride are also often found in concentrations higher than the recommended standard. In places where surface water sources are not available or are limited, rainfall is low and groundwater salinity is high, the only possible supply of drinking water is from desalination.

Solar distillation was, until recently, the world's leading desalination technology. Its appropriateness for remote community water supply however is questionable. Reverse osmosis desalination has now superseded distillation and has been applied in the provision of drinking water worldwide.

Reverse osmosis is a pressure driven membrane separation technique which has traditionally required very high pressures. Recently, low pressure membranes have been developed which operate at much lower pressures and, though not suited to seawater desalination, are ideal for the treatment of brackish water allowing a high production rate and a lower energy demand.

The process has, however, remained a highly technical one requiring skilled supervision and ongoing maintenance. Its appropriateness for application in remote communities is therefore doubtful. Further, its energy demand, even with low pressure membranes, has made its adaptation to solar power an extremely expensive option.

The Remote Area Developments Group (RADG) of Murdoch University has been investigating the process with a view to adapting it for remote applications. The criteria for successful adaptation are seen as,

1. Simplicity
2. Low cost
3. Low maintenance
4. Robustness.
DEVELOPMENT STRATEGY

The Reverse Osmosis Hardware

The amount of water treated per membrane is restricted to about 10% as higher recovery ratios may lead to rapid membrane deterioration. Very small units, typically run from generators, may use only one or two membranes and so achieve recovery ratios of only 10-20%. They require a much lower degree of pre and post treatment than the common larger units and brine disposal is much less of a problem. The brine is only slightly more concentrated than the feed but there is a lot of it, as 80 - 90% of the feed is rejected, but can be used for other domestic purposes.

Accordingly, for every litre of fresh water produced, up to 10 litres of feed water has to be pumped up to the system pressure. In terms of the hydraulic energy requirements the process is quite wasteful and makes adaptation to solar power a very expensive option. Also, since the system pressure and recovery ratio are determined by a throttle valve on the reject line, regular supervision and adjustment would be required to cope with the varying supply of power from the solar array.

Great savings in energy can be gained by using this still pressurised waste stream to assist in the pumping of the feedwater. The 'Powersurvivor' unit uses this arrangement and has been quite successful, although its output is restricted. No operating adjustment is necessary - or possible, and the unit looks after itself throughout the day. It operates on about one fifth of the power it would need if it did not recover the energy from the brine stream.

The RADG group has been developing a much larger unit to supply the needs of a small community based on similar principles. In the majority of cases, the salt removal efficiency does not need to be very high. Salinities of 3000 - 5000 ppm need only be reduced to 1500 ppm to meet the required NHMRC standard for drinking water. Ongoing testing of the new range of low pressure membranes will continue to determine the best combination of flux rate, removal efficiency and cost.

Solar Tracking

A Perth company, Solar Track Pty Ltd, has invented a robust and reliable solar tracker which has only two moving parts - the two bearings. The solar tracker operates purely on the weight difference between the two half-shaded copper cylinders, each partly filled with liquid Freon. When one cylinder heats up more than the other, more Freon evaporates which forces the liquid Freon below it into the other cylinder. The weight difference rotates the tracker, keeping up with the sun all the time. A patented device in the upper shade gives the tracker a kick back last thing in the evening. As the panels cool, gravity takes over and the tracker rotates back to face the east, patiently awaiting the dawn.
The typical summer production pattern of the 'Powersurvivor' coupled to the solar panel is shown in Figure 1.

![Graph showing typical summer production pattern](image)

**Figure 1.** The hatched area represents the increased production of fresh water resulting from the use of solar tracking and pump optimisation.

**Pump Optimisation**

Solar panels don't produce power like a battery does. A battery provides the power at its designed voltage, say 12 V, and provides the current that the motor requires, say 4 A. The output from a solar panel is dependant on the strength of the sunshine (insolation) and power is provided in a range of Voltage/Current combinations. A Perth company, Solar Focus, produces a Pump Optimiser which keeps the voltage output up so that the output from the panel is always near its maximum.

**Miscellaneous Controls**

Unlike most larger scale RO plants, it is anticipated that no other control mechanisms will be required. It should be stressed that every control mechanism requires some power, is a source of failure and adds to both the capital and maintenance costs. In keeping with this philosophy, the pump is connected through the optimiser directly to the solar array and not through a battery bank. Batteries are only 70%, efficient. so 30% of the power from a solar array is lost if batteries are used. Further, since only a fixed amount of solar energy is available per day, it is considered more efficient to store that energy as water than to store it as chemical/electrical energy.

**TESTING RESULTS**

Tests have demonstrated the benefits of the solar tracker and the optimiser on production rates. The tracker in particular produced a significant increase in production while allowing a rapid startup in the morning. The tracker and optimiser together nearly doubled the production of fresh water. From these results, it is likely that the maximum daily duration of production (in January in Perth or October in the north of the
State) will be 11 to 12 hours. The maximum production rate from the Powersurvivor is approximately 65 litres a day.

EXPECTED OUTPUT OF LARGER UNIT BEING DEVELOPED BY RADG

A computer model which takes into account energy recovery has been developed and by using low pressure membrane, a production rate of \(83.7 \text{ L/h}\) is expected in summer bright sunshine conditions. The experiments conducted on the Powersurvivor demonstrated the extremely long duration of pumping that can be achieved using a solar tracker and solar optimiser. Summer pumping in Perth would therefore produce \(1000 \text{ L/day}\) from just two solar panels.

CONCLUSION

Solar powered reverse osmosis has the potential to make a significant contribution to the health and wellbeing of remote communities whose water sources are not to the required drinking standard. Solar panels are maintenance free, have a life expectancy in excess of 15 years, are clean, quiet and environmentally sound. Their only failing has been their comparatively high capital cost. The use of energy recovery on the RO plant can reduce the number of panels required to one quarter of that normally required. To this end, the Remote Area Developments Group's goal is to develop the technology to produce up to \(1000 \text{ L/day}\) of fresh water from brackish water sources, from the power of only two solar panels, with the aid of,

1. energy recovery of the waste stream,
2. low pressure membranes,
3. solar trackers
4. pump optimisers
5. Australia's abundant sunshine.
ON SITE BACTERIOLOGICAL TESTING OF WATER IN REMOTE ABORIGINAL COMMUNITIES

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Bacteriological water quality in remote communities is difficult to test because of distance to health laboratories and the need to collect samples under strict aseptic conditions and to bring the samples to the laboratory within 24 hours. This paper provides details on an investigation currently under way into the use of self contained bacteriological testing kits in remote Aboriginal communities.

BACKGROUND

The Water Authority of Western Australia has responsibility for the monitoring of water quality for Aboriginal communities in remote areas of the State, such as the Pilbara, Western Desert and Kimberley regions. At present, water quality monitoring is achieved by collecting a sample from a source on a regular basis, usually once a month, and chartering an aircraft to deliver this sample to a central testing laboratory, located at the Queen Elizabeth II Medical Centre, Perth. Chartering is necessary because the sample must arrive at the laboratory within 24 hours to be valid.

Only a limited number of communities are tested at present. In the Pilbara, the communities of Jigalong, Yandearra and Warralong are sampled monthly and Punmu is sampled every quarter. The following communities are not sampled at all. Milyakirri, Well 33, Parnggurr, Kuta Kuta, Camp 61, Billanooka, Walgun, Robertson Range, Pundawarrie, Ngarrawana, Gurradunja and the Wapet road bores on the way out to Punmu. The 'Strelley Nomad' communities of Mijijimaya, Callawa, Coongan, Carlindi, Lalla Rookh and Strelley are also not monitored, as the Strelley Nomads do not want the Water Authority to be involved with their communities. No detailed information is available as yet for the Kimberley, but an estimated 100 small communities have no water quality monitoring at present. It should be noted that most of the communities which are not tested are very small (30 or less people) and can be totally uninhabited for several months.

Total and faecal Coliform counts (tested for at 37 and 44 degrees centigrade respectively) and detection for amoebae are performed for all samples, and samples showing high background growth counts are examined for salmonella.

The current procedures for analysis of water samples from remote areas detailed above have various drawbacks:
* a large number of small communities which do not get tested
* it is difficult to guarantee that samples arrive within the necessary time period. If samples are delayed, another sample
must be collected. This does not protect the community effectively and is costly
* the system has little flexibility, and can break down in emergency situations, such as when there is a marked increase in water related illness, flooding etc
* Water Authority personnel often do not have sufficient time to carry out other tasks on site such as routine maintenance, checking of facilities etc, because aircraft must leave promptly to ensure delivery within 24 hours
* it typically takes 5 or 6 days to analyse a sample and get the result to an inspector using the current system. Thus, if contamination is discovered, it is likely that much of the community will have been exposed before any warning can be given or remedial action taken
* high costs. In particular charter of an aircraft once a month costs about $16000 per annum

Use of a portable, self contained testing kit by local members of the community or eg community nurses would address these shortfalls, allowing more effective water quality monitoring at significantly reduced cost.

The objectives of the study are:
* to test the technical applicability and accuracy of various commercially available kits
* to undertake a pilot training scheme in kit usage. This is targetted at members of local communities, but other people, such as community health nurses, may be trained as well
* produce a cost / benefit analysis, comparing the current situation with projected scenario if kits were introduced
* produce a draft training manual and, if additional funds can be found, a training video on the kit which is found to be the most appropriate for use in remote Aboriginal communities

Training in kit usage will form an advanced module in the Environmental Health Worker (EHW) Training Programme, which is taught at Pundulmurra College, Port Hedland.

WATER TESTING KITS

A range of different types of proprietary water testing kits are available. These are based on two basic methods:
* the membrane filtration (MF) technique
* the 'most probable number' (MPN) or multiple tube technique

These are described below, together with a range of advantages and disadvantages related to each method, which have either been found in the literature or identified during the project.

Membrane Filtration Technique

A minimum volume of 10 ml of the sample is introduced aseptically into a sterile or properly disinfected filtration assembly containing a sterile membrane filter. A vacuum is applied and the sample is drawn through the membrane filter. All indicator organisms are retained on or within the filter which
is then transferred to a suitable culture medium in a petri
dish. Following a period of resuscitation, during which the
bacteria acclimate to their new conditions, the petri dish is
transferred to an incubator at the appropriate temperature where
it is incubated for a standard time period. The bacteria
multiply during incubation, producing visually identifiable
colonies. These colonies are counted, and results are expressed
in terms of colony forming units (cfu) per 100 ml of sample.

The filtration unit and associated equipment, such as sampling
cup and measuring cylinder, must be sterilised after each sample
is processed. This is generally achieved in the field by burning
methanol in the absence of oxygen to produce formaldehyde, a
potent, gaseous sterilising agent. Equipment is designed to
allow oxygen free burning of methanol.

Principal advantages of the membrane filtration technique are:
* it is the technique used by central laboratories, and thus
direct comparison
of results obtained is possible
* a large number of samples can be processed routinely, giving
more
representative samples and the opportunity to run samples in
duplicate or
even triplicate
* cost for consumables per test is lower than for the MPN
technique
* results are obtained in approximately 24 hours, as compared
with 48 hours
or more using the standard MPN technique. Note however, that
certain
advances have been made on the standard MPN technique which
produce a
result in 24 hours. These are described below
* the equipment used is reasonably compact, portable and durable

Drawbacks of MF techniques include:
* the physical manipulations required to produce a result
increase the chances of contamination from external sources
* if sterilisation of filtration equipment is not performed
properly, carry-over from previous sample may occur
* the two factors cited above make training needs for effective
kit usage significant
* sterilisation in the field can be time consuming if several
samples must be
processed (fifteen minutes is required for each sample)
* MF techniques may be interfered with by:
  * high turbidity waters, caused by clay, algae etc which
can interfere with filtration and produce a deposit on
the membrane that could interfere with bacterial growth
  * the presence of a relatively high non coliform count.
This can interfere with the determination of coliforms
  * toxic substances in the test water that may be
absorbed and concentrated on the membrane and affect the
growth of the coliforms

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Two proprietary kits using MF techniques are being trialled, produced by the companies of Delagua and Millipore respectively.

**Delagua**

The Delagua Water Testing Kit was developed on behalf of the charity organisation Oxfam by the Robens Institute, based at the University of Surrey, England.

The kit is extremely compact, being roughly the size of briefcase, and contains:

* a combined measuring funnel and filtration unit
* an incubator which can run off its own rechargeable power source, a car battery or mains electricity (via a transformer). The incubator can process sixteen samples at one time. Operating temperature is 44 degrees Centigrade, allowing enumeration of faecal coliforms only
* a kit for determining chlorine residual and pH of samples
* a simple kit for determining water turbidity
* sufficient storage compartments for all consumables and a reasonable set of spare parts

The kit was developed primarily for use in developing countries, and employs resterilisable petri dishes and culture media bottles. The incubator is designed specifically for the aluminium petri dishes. These are rather smaller than the one-use plastic petri dishes used by the Health Department laboratories, and thus changing to use of one-use plastic petri dishes is not straightforward. The need to employ resterilised petri dishes increases training needs and the possibility of getting a wrong result due to contamination.

**Millipore**

Filtration apparatus and incubator are contained in two separate briefcase size units. The equipment is of extremely high quality and robust construction. This is reflected in the cost of equipment, which is roughly double that of the Delagua kit. Methanol sterilisation is considerably easier to perform and more likely to be effective using the Millipore system. This is because the methanol is introduced onto a 'wick' built into the filter base, rather than simply squirting an estimated volume of methanol into the equipment, as is the case with the Delagua kit.

An incubator is available which can process samples at 37 and 44 degrees centigrade simultaneously, allowing enumeration of both total and faecal coliforms. The incubator requires an external 12 volt power source, such as a car battery. The total bulk of equipment required to perform on-site tests with the Millipore system (filtration unit, incubator and transformer/power source) is considerably greater than the Delagua kit.
Other options using MF techniques

Certain other possibilities have been identified using MF techniques.

Delayed Incubation

It is possible to treat the filtered membrane with a special 'holding' media which preserves bacteria for up to 72 hours. This has the advantage that samples have more time for transport to the central laboratory, but has the disadvantage that the community has to wait longer for a result to be produced. Delayed incubation techniques are being tested in conjunction with other methods.

Millipore 'Milliflex' system

This system combines a measuring funnel, membrane filter holder and the filter itself in a 'one use' plastic unit which is supplied in a sterile container. After filtration, the measuring funnel is sheared off from the membrane filter housing and thrown away. The filter is housed such that it can be transferred to a petri dish without the need for forceps, significantly reducing the chance of external contamination. The researcher is currently pursuing the possibility of trialling this method in the field.

Most Probable Number Technique

In the standard MPN method different amounts of water are added to tubes containing a suitable culture medium. This requires the use of sterile glass pipettes and test tubes. The bacteria present in the water reproduce and, from the number of tubes inoculated and the number with a positive reaction, the most probable number (MPN) of bacteria present in the source water can be determined statistically. A double incubation lasting a total of 48 hours is required to test for faecal coliforms. Incubation must occur for 24 hours at 37 degrees and for 24 hours at 44 degrees. The complexity and longer time period needed to get a result meant that this method was originally excluded from investigation. However, a research of the literature showed that an improved MPN technique is now available. This is marketed by Palintest, and is known as the Colilert system.

Colilert

Sterile, pre-packed, sealed test tubes are available which contain all necessary reagents. 10 ml of the sample water is added to each of either five or ten tubes, depending on the result accuracy required. The test tubes are incubated for 24 hours at 37 degrees centigrade. Total coliforms are established by colour change in test tubes under normal light. Faecal coliforms are checked by assessing fluorescence of test tube contents under UV light. Results can only be quoted in terms of a 'most probable number', that is, precise enumeration is not possible. A portable UV torch is available for use with the kit. No specifically designed incubator to carry out this test has
yet been identified, although the Australian representative of Palintest, Crown Scientific, have kindly provided a large incubator to allow testing of the method.

Principal advantages of the Colilert system are:

* it is very simple to use, leading to:
  * reduced need for training
  * less possibility of wrong result due to user error or contaminated equipment
* significantly less time needed to process a sample, taking into account the need for methanol flaming using MF techniques
* both faecal and total coliforms can be tested for using one temperature, allowing simpler and probably more compact incubator design

The drawbacks of the Colilert system include:

* test for test, it is much more bulky than MF methods. An estimated maximum of six samples could be processed at one time in an incubator small enough to be considered portable
* incubation temperature of 37 degrees cannot be guaranteed in Australian outback conditions. The sensitivity of the test to higher temperatures is to be investigated
* the glass test tubes, although reasonably durable and well packed, would be susceptible to breakage during transport along dirt roads
* positive samples take on an appealing yellow colour. Disposal of test tubes and contents would need careful training and policing to avoid eg children trying a sip of cultured bacteria

Other Options for Field Testing

A method is described in the literature whereby water is screened for faecal pollution by detection of production of hydrogen sulphide. The presence of coliforms in water is associated with organisms which produce hydrogen sulphide.

The method is extremely simple, and requires a minimum of equipment:

* medium is prepared in a central laboratory, and 1 ml of the medium absorbed onto eg folded tissue paper. This is placed in a 20 ml bottle, sterilised, dried and sealed
* bottles are then transported into the field, for storage at convenient distribution points
* water is tested by filling the bottle, and allowing it to stand at ambient temperature reported at 30 °37 deg. C
  * faecal pollution is indicated if the contents of the bottle turn black within 12 to 18 hours

This method is not thought to be a useful replacement for areas where more accurate determination is possible, however, in extremely remote locations, or where a large group of people are gathered for a short time (for instance at a law meeting) or
where a trained individual is simply not present, this test may be of particular use.

Tests are currently under way in the central laboratories in Perth to ascertain the detection level for faecal pollution using the method, and whether temperatures in excess of 40 degrees centigrade affect results.

PRELIMINARY FINDINGS

A range of findings have already been described above. Other important findings to date are described briefly below. The majority of work to date has involved the Delagua kit as equipment and consumables for other kits have only recently become available. The study is due for completion in December 1991 and is at present on schedule.

Parameters tested on-site.

It is not practical to assess for amoebae and probably salmonella on-site, and thus portable testing kits should generally be viewed as an augmentation rather than a substitution to current sampling procedures. However, NH&MRC guidelines on Desirable Quality for Drinking Water in Australia point out that: 
"...it is far more important to examine numerous samples by means of a simple test than occasional samples by a more complicated test."

It is also important to remember that a large number of emerging communities have no monitoring at all at present.

Training

EHW workers have been trained in usage of the Delagua kit. Major aspects requiring attention are techniques of sterilising reusable equipment, how to count colonies after culturing, and the need to time various steps in the experimental procedure, as EHW's do not commonly have access to a watch or clock. At this stage, it appears logical to avoid the need for training in resterilisation techniques by use of the Millipore kit or development of 'one use' petri dishes etc for the Delagua kit.

Counting of colonies is not simple to teach. The character of cultures can vary significantly in size, definition and colour making it difficult to specify a teaching package which will allow EHW's to gain the skill within a reasonable time. However, training exercises to date indicate that the basic skills could be acquired in a classroom situation and then refined over a couple of months of working in the field. It is possible to gain a 'feel' for interpreting colony counts.

It is important to keep in mind that training in remedial action if a source is found to be contaminated is also important, such as shot dosing with chlorine tablets.
Timing of procedures.

The sensitivity of timing methanol sterilisation has been investigated for the Delagua kit, and incubation time has been investigated for both the Delagua kit and the Colilert kit. Notably, the study has found that no carryover occurs between consecutive samples even if methanol flaming is totally omitted, providing the equipment is dried between filtration runs. There is thus considerable margin for error in methanol sterilisation technique.

Incubation time can be varied between 14 and 20 hours using the Delagua kit without significantly affecting colony counts. Any less than this and colonies may be too small to identify reliably, any longer and petri dishes tend to dry out, which makes enumeration much harder.

The Colilert system requires a minimum of 24 hours incubation to be sure of a result. Incubation for longer periods may indicate that water is more polluted than it actually is. A nominal maximum of 28 hours incubation is recommended.

Contamination Carryover.

The chances of carryover or contamination have been investigated using the Delagua kit due to introduction of faecal contamination to:
- underside of petri dish lids
- absorbent pads
- reverse side of filter membranes
- culture medium

With the exception of the underside of the petri dishes, no false positives have been recorded. When introduced to the underside of the petri dish, one sample from four produced a single colony. This is encouraging, in that there is apparently a large margin for error in aseptic technique without producing false positives.

False Negatives

The Delagua kit has produced a small number of false negative results, while being compared with the Colilert system. This means that a water known to be unfit to drink appeared to be safe. The reason for this is still being pursued, but the fact that this is occurring is obviously a cause for concern. The researcher has established that the false negatives are not due to excess methanol remaining within the filtration apparatus after sterilisation.
Possible Uses.

Specific uses for portable water testing kits identified to date include:

* **water quality monitoring at bush gatherings** - this is not practical to undertake using current methods, but is simple with a portable kit
* **water quality monitoring for very small, very isolated or sporadically populated communities** - This is not done at present, and, realistically, it is unlikely to be practical to perform without using a portable kit of some description
* **education** - to give visual reinforcement to general health and hygiene education
* **equipment monitoring at commissioning** - portable kits allow UV sterilisation units to be tested while fitters etc are still on-site. This is not possible using current methods.

CONCLUSION

It can be said that there is a reasonable range of equipment available on the market for the testing of water quality in remote areas. The current situation whereby bottles need to be flown to Perth within 24 hours makes adequate monitoring a difficult, if not impossible task. Use of perhaps two types of proprietary kits with minor modifications by a trained person based in the community would considerably improve the frequency, standard and coverage of water quality monitoring in remote areas. The kit to be used will vary depending on facilities available, such as a power source, the training level and skill of the user, and the accuracy of result required in a given situation.

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THE REMOTE AREA TECHNOLOGY CENTRE
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Appropriate Technology for remote Aboriginal communities is required due to the failure of many European technologies under these circumstances. Based on appropriate technologies developed by the Remote Area Developments Group and others, a manufacturing centre has been established at Pundulmurra College. The aim, operation and display facility of this Remote Area Technology Centre is described.

INTRODUCTION

The philosophy of appropriate technology (A.T.) was developed as a direct result of the failure of many European technologies to adequately address themselves to the conditions in remote and third world communities.

In Australia A.T. was first grasped and developed by the centre for Appropriate Technology (C.A.T.) in Alice Springs. The centre began modestly in 1980 and under the direction of Dr. Bruce Walker, has evolved into a world leader in its field. It now employs 14 full time staff continually developing producing and training in the field of appropriate technology.

In 1985 it was becoming increasingly apparent that research in a similar direction was needed in WA. This research had been neglected in the past despite ample evidence of ill health, environmental deterioration and wastage of public monies due to misinformation, lack of knowledge and lack of appropriate technologies.

REMOTE AREA DEVELOPMENTS GROUP

To service this need the Remote Area Development Group was established at Murdoch University. Over the last 5 years this group has focused on research and design for improving sanitation and hygiene in remote communities. During 1990 their design for an improved ablution facility, modelled on units from Alice Springs, was trialed at a number of communities.

Following the acceptance of these trial units, it became apparent that a production base was required for their fabrication - along with other appropriate technology devices.
A funding arrangement between TAFE Aboriginal Access and Pundulmurra College resulted in the formation of the Remote Area Technology Centre at Pundulmurra College in February of this year.

AIMS AND OBJECTIVES OF THE R.A.T.C.

1. Research, design, test and manufacture technologies appropriate to Aboriginal lifestyles thereby enhancing self reliance, self determination and enterprise of Aboriginal people.

2. To maximise the involvement of Aboriginal people in the design, selection, production and maintenance of appropriate technologies.

3. To provide technical advice, information and options to further the technological and economic development of Aboriginal people.

4. To provide training in not only practical skills but also management techniques to facilitate the establishment of a core management group able to plan, chart and oversee the future operation of the R.A.T.C.

Following an establishment period the R.A.T. Centre began production in May, 1991. A wage subsidy agreement with DEET was entered into and 2 full time Aboriginal personnel employed.

The leading hand, Ashley Graham from Carnarvon, is a qualified builder, and his value to the R.A.T. Centre cannot be over estimated. His self motivation, positive work ethic and superlative handskills make him the R.A.T. Centre's most valued asset. A training program is now being prepared to enable him to assume the role of R.A.T. Centre manager during 1992. The second employee, Gordon Colley from Jigalong is another highly valued member of the R.A.T. Centre team. Gordon has massive enthusiasm for the project and is rapidly acquiring the range of skills required to fabricate the range of R.A.T. Centre products.

These products are specifically designed for use in remote communities and include equipment such as pre fabricated steel framed pit toilets, the Murdoch designed remote area hygiene facility and variations of that design, chip heaters, hand powered washing machines, "plastic" solar hot water systems and canvas goods (chiefly groundsheets and "swags").

It should not be seen that the R.A.T. Centres production base is static. The objectives of the R.A.T. Centre, stated earlier are to produce appropriate products for Aboriginal people and to maximize their involvement in their design, selection and manufacture.

Aboriginal groups are strongly encouraged to contact the centre should they have a particular need or an existing technology is failing. It is only through this sort of communication that
Aboriginal group can be supplied with the type of hardware that they desire and hardware that is produced by Aboriginal people. Keeping the Aboriginal dollar with Aboriginal people.

THE APPROPRIATE TECHNOLOGY PARK

A major goal of the RATC is to establish, adjacent to the enterprise facility an Appropriate Technology (AT) Park or display facility.

This Park will enable members of remote Aboriginal communities, as well as those from the mining and rural community to see, test and evaluate appropriate technology devices before committing funds.

Those who are familiar with the development of remote communities are also familiar with the wastage of millions of dollars of monies due largely to inappropriate "hardware" being supplied to remote communities.

The concept of the display facility at Pundulmurra is not purely to display and market the products of the RATC but also as a research and display vehicle for the RADG and also for companies from within the private sector. Local schools are also most keen to use the area to aid in teaching science and social studies units.

By accessing these 3 major production bases we have attracted as a minimum the range of relevant devices as listed below:

- Remote Area Hygiene Facility (Murdoch).
- V.I.P. Toilet (CAT Alice Springs).
- Chip Heater (CAT).
- Portable Canvas V.I.P. (RATC).
- Incinerators (RATC).
- Waste Management Hardware (RATC).
- Portable Canvas Shelters (Ardeco, RATC).
- Swag Rolls, Ground Sheets (RATC).
- Stressed Frame, Portable Meeting Place Shelters (RATC).
- Solar Lighting
  - Solar Pumping
  - Solar Tracking
  - Solar Stills
  - Wind Turbine
  - Solar Power Units (self contained)
  - Windmills
  - Windmill powered reverse osmosis (Murdoch)
- Remote Area Communications (Telecom)
- Nursery Products - Pundulmurra
- Septic Tank/Leach Drain - Shire of Hedland.
- "Plastic" Septic Tank/Leach Drain (INNOTECH)
- "Plastic" Solar Hot Water System (SOLCO)
THE LOCATION – PUNDULMURRA COLLEGE

The logic defining the need for an AT Park is undeniable. Again logic suggests that it must be at a location as accessible as is possible to the remote community of the Pilbara and Kimberley.

Pundulmurra College fits this bill well. Being the only Aboriginal College of its type in Australia, Pundulmuura maintains a high profile in this region. Apart from the 80 Aboriginal students attending mainstream courses, there is a constant stream of visitors both from remote communities and from central governmental bodies, flowing through Pundulmurra. These visitors may be attracted to Pundulmurra for short term intensive training courses, regional meetings, conferences (for example the National Environmental Health Conference in October is being hosted by Pundulmurra – over 200 will attend), for personal business and, when the AT Park is established, to view and discuss technical options for community development. In addition as all equipment within the Park will be functioning this area can be used for training purposes either for appropriate technology courses or to fit the Environmental Health Worker Program.

The construction of the first stage of the AT Park is well underway at the time of this paper and will be finished in time for the October Environmental Health Conference. Planning for the second stage is now underway and centres around the construction of a display home which demonstrated remote area architecture and will incorporate a range of appropriate technology and renewable energy features. Construction of this home is planned for 1992.

Should any group wish to view this display area or require further information on either the Appropriate Technology Park on the Remote Area Technology Centre, please do not hesitate to contact the centre.
The term Appropriate Technology is gaining recognition and acceptance world-wide, although it may conjure up different pictures to different people. To help define and promote appropriate technologies by a hands-on approach, a display of technologies developed at Murdoch University and elsewhere is being developed at an appropriate technology park at Murdoch University. This is a unique attempt in Australia that will include research and development as well as training of graduate and undergraduate students.

INTRODUCTION

The concept of Appropriate Technology was first synthesized by the British economist E.F. Schumacher. He had picked up his insights from self sufficient village development model suggested by Mahatma Gandhi of India. Appropriate technology is "a technology tailored to fit the psychosocial and biophysical context prevailing in particular location and period, (Willoughby 1990) to appropriate technology will have any one or several of the following characteristics (Jequier and Bhané, 1983):

* low investment cost per work place
* low capital investment per unit output,
* organisational simplicity
* high adaptability to particular social or cultural environment
* sparing use of natural resources
* low cost of final product
* high potential for employment

As environmental awareness has increase in the latter part of 1980's appropriate technology is expected to include the following also:

* based on renewable energy
* produces minimum waste
* consumes minimum energy
* by products should not produce any environmental pollution and
* encourages a sustainable life style

Appropriate Technology was assumed to be more suitable for developing countries where high technology was not suitable. But due to environmental constraints, appropriate technology has now world wide importance and application.

The proposed Appropriate Technology Display Centre aims to encourage the people of Western Australia to practise the options available in the area of Appropriate Technology.

BACKGROUND

The Remote Area Developments Group (RADG) at Murdoch University was established in 1985 to investigate the problems of small communities in remote areas. Research relevant to these areas has been neglected in the past although the prevalence of ill
health, environmental deterioration and lack of appropriate technology suggest there are significant needs. It is widely acknowledged that many people in remote areas, particularly Aboriginal people do not enjoy the same standards of living and health care as do people living in the cities. The quality of community health and life have their relationships to water supply and sanitation. RADG identified the areas of research to be taken up (Mathew 1988) and began their work by focussing on appropriate technology for water supply and sanitation in remote Aboriginal communities.

The Remote Area Hygiene Facility (RAHF) with pour-flush toilet, shower, laundry, hand washing machine (CAT), chipheater (CAT), solar hot water system and evapotranspiration system for wastewater disposal was designed and constructed as a display unit in a display area established to promote the technology developed by RADG. The display unit was inaugurated in conjunction with a seminar in 1989. Later on it was felt that the land area was not sufficient to display all the technologies developed by RADG.

In 1989 the National Health and Medical Research Council offered a Public Health Travel Fellowship to Kuruvilla Mathew to visit appropriate technology centres in many parts of the world and he visited USA, Canada, Netherlands, India and England. The necessities of establishing an appropriate technology display centre was recommended in the report of the visit submitted to NHMRC (Mathew 1989). In 1990 Damian Randle of the Appropriate Technology Centre in Wales visited Western Australia and conducted a seminar about the purpose and function of the centre he is in charge of in Wales. Members of RADG visited the Centre for Appropriate Technology in Alice Springs and the display area which provided added enthusiasm.

RADG has taken up the idea seriously and submitted a request to the Institute for Environmental Science for the establishment of an Appropriate Technology Display Centre. The Institute for Environmental Science has launched a research appeal including this as one of the projects with an estimated cost of establishment of $200,000. Subsequently a submission with a schematic plan was given to the university to allot a hectare of land for the establishment of the centre.

Appropriate Technology Parks in Australia

The Centre for Appropriate Technology in Alice Springs has a display area (Walker 1982) and a similar centre is now being established as part of the Remote Area Technology Centre in Pundulmurra College in South Hedland, with the assistance and collaboration of RADG.

According to the study conducted by Cartes and Newman (1991) there are twenty Science and technology parks in Australia developed in association with universities. The Western Australian Technology park near Curtin University is the only established one in Western Australia and deals with high technology. No other university has established an appropriate technology park.
CREATECH

Don Harrison and his wife Shauna Harrison have suggested the name Centre for Renewable Energy and Appropriate technology (CREATECH) for the display centre.

CREATECH will have the following functions:
* To provide RADG with an area where their research projects can be developed, tested and displayed
* To promote RADG projects and products to industry, research organisations, government departments and funding agencies
* To promote the role and importance of implementing renewable energy options and appropriate technology in general
* To have an on site office and seminar and display facility where developers, planners, funding agencies, researchers and university people can co-operate and work together for the promoting of appropriate technology.
* To provide a place where community groups, schools and environmental groups can visit, learn and develop better understanding of appropriate technology
* To form an appropriate technology reference centre for dissemination of information on appropriate technologies available in Australia and elsewhere.

To achieve the above functions, the display area will be divided into subsections for different displays.

CREATECH DISPLAY DETAILS

To meet the aims and functions of CREATECH the following display will be organised:

* All the technology developed by RADG will be displayed at the centre. This will include the Remote Area Hygiene Facility, solar desalination unit, wind powered desalination unit, solar lighting facility and pour flush for the toilet. Along with this there will be display boards explaining the work of RADG such as the revegetation of communities, enterprise development projects, and remote area communications.

* The technologies developed at the Centre for Appropriate Technology in Alice Springs and Remote Area Technology Centre, Pundulmurra College at South Hedland will also be displayed at the Centre.

* There will be separate areas for appropriate technologies on solar energy, wind energy, water supply, waste disposal and other technologies

* A solar house will be constructed to be used as an office and seminar area. The construction of the house will take into consideration the construction techniques and solar principles so that the building will not only house facilities but itself will be also a display.
Another separate building may be also constructed for display purpose alone. This will house technologies developed outside the university.

An information dissemination centre with a computer data base of appropriate technology activities from around the world also will be established.

MANAGEMENT

The Centre will be administered by RADG with the appointment of a manager/caretaker. The land belongs to the University. The establishment cost is expected to be funded by the appeal of the Institute for Environmental Science. RADG will seek advice from Murdoch University Energy Research Institute (MUERI) and the Institute of Science and Technology Policy (ISTP) and the Property Office of the University.

The maintenance of CREATECH is expected to be met from grants from government, RADG research funds, rent collected from industries who present displays and from fees collected from the community for use of the Centre.

The location of CREATECH will be on the south side of the proposed science park. All the necessary services are available at the site.

CONCLUSION

The vision of RADG to establish an Appropriate Technology park is a unique attempt in Australia. It may take a few years to establish it completely. The role of the park in promoting appropriate technology will be significant. This will take the form of research and development in appropriate technology as well as training of graduates and undergraduate students. The efforts will help disseminate ideas on a more environmentally acceptable and sustainable life style.

REFERENCES


A plant nursery has been established at Pundulmurra College with the ultimate aim of improving health standards in Aboriginal communities. How this is to be achieved is outlined.

A plant nursery has recently been established at Pundulmurra College.

It has 3 distinct roles -

1. Provide native plants for revegetation of Aboriginal communities.

2. Provide communities with exotic fruit trees that will grow in the Pilbara.

3. Provide an advisory and training service to those communities who are keen to grow trees.

These are all aimed at improving health standards in communities.

Growing trees can help improve health by:

1. Controlling dust which causes eye and skin diseases with shelterbelts and ground covers.

2. Making communities cooler with shade trees.

3. Improving nutrition with plant foods which can be incorporated into shelter belts and amenity plantings.

4. Increasing access to plants that can be used for medicine which once again can be incorporated into shelterbelts and amenity planting.

5. Trees planted for firewood and artifacts reducing pressure on existing vegetation resources.

6. Amenity plantings greening communities creating a much more pleasant environment to live in which makes people feel better.

7. The creation of microclimates to assist in the growing of exotic food plants that would otherwise struggle to survive in the Pilbara climate.

8. Plantings on evapotranspiration trenches reducing problems with exposed and excess waste water.
HOW DOES ALL THIS HAPPEN?

Before such plantings can happen in communities a number of factors have to be considered and dealt with. These are -

1. Adequate water supply.

2. Efficient low maintenance irrigation system to get this water from the supply to the plants.

3. Identification of the most appropriate methods of revegetation.


5. Weed control which does not involve regular weeding.

6. Plant protection from -
   - children
   - stock such as horses and cattle
   - motor vehicles
   - dogs
   - raking

7. An appropriate program to disseminate this information to Communities so that they can discuss these issues and have their say.

8. Identification of the best way to implement these programs if Communities desire them. This includes such things as employment opportunities, training opportunities, machinery and equipment requirements.

Pundulmurra will be producing a book with more detailed information on revegetation. This will be available for those people and communities who are interested. Pundulmurra is also available to visit communities to talk about their revegetation needs.

ACKNOWLEDGEMENTS

The assistance of Greening Australia with funding to initiate the nursery is gratefully acknowledged.
DIRECT SEEDING: AN APPROPRIATE TECHNOLOGY FOR THE REGENERATION OF DEGRADED ABORIGINAL LANDS

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This paper presents a review of techniques for revegetation of Aboriginal communities used in Central Australia. These experiences provide data for developing revegetation technologies for Western Australia.

VEGETATION MANAGEMENT AND ABORIGINAL COMMUNITIES.

Vegetation management is not a new concept to many Aboriginal people. Traditional vegetation management practices such as patch burning required a thorough understanding of the ecology of vegetation communities, vegetation succession, and the associated fauna. Burning was not carried out indiscriminately but rather, informed decisions were made in response to the vegetation type, season and the time since the last burning (Walsh 1989). It has even been said that the traditional Australian landscape was an Aboriginal artefact, maintained in its pristine form by conscious Aboriginal management (Coombs 1989).

However, with European contact and the establishment of permanent Aboriginal settlements, the pattern of vegetation use by Aboriginal people living in remote settlements in the arid and semi-arid regions of Australia has undoubtedly changed.

Permanent settlements of Aboriginal people have brought about an increase in the people-pressure exerted on the land and vegetation surrounding those settlements. Whereas in the times before European contact people would move on when their impact on the local vegetation and fauna became detrimental to the environment and themselves, the advent of permanent settlements with regular supplies of food and water have provided very strong incentives for Aboriginal people to remain in a degraded environment, even though the environmental impact of a concentrated population on a relatively small area is clearly severe.

The practice of living a community lifestyle that degrades the local vegetation and subsequently creates health problems for the members of that community is of course not unique to Aboriginal communities. It is a problem that faces not only other users of the arid and semi-arid lands of Australia but most other communities in the world today. Nevertheless, the link between community health and the vegetation status of the surrounding environment is much more direct in remote Aboriginal communities than in other communities in the arid and semi-arid regions of Australia.

Aboriginal people living in remote communities in the arid and semi-arid regions of Australia often have a high dependance on
local resources for food and firewood (Walsh 1989). Furthermore, Aboriginal people also spend a great deal of time outside their houses and are therefore very susceptible to dust borne diseases. In a significant report upon the health and lifestyle of Aboriginal people in Central Australia, it was observed that 80% of Aboriginal people spent 80% of their time outside the house in their back yards (Nganampa Health Council Inc. et. al 1987). The people of remote Aboriginal settlements thus experience a much greater degree of ill-health and discomfort than other people in arid and semi-arid Australia as result of vegetation denudation.

Clearly, vegetation management is an issue that must now be faced in a new way by Aboriginal communities. This does not mean that the traditional pre-contact methods of vegetation management should be rejected, for in many areas traditional methods such as patch burning may be ecologically sound (Burrows, Ward and Robinson 1991) and very compatible with contemporary community functions (Walsh 1989). However, because of changes in lifestyle and vegetation use, these methods alone are not enough and new methods that are are also ecologically sound and compatible with community functions must now be adopted, adapted or developed in order to cope with these changes.

DIRECT SEEDING AND SOIL SHAPING

A technique that appears to have a lot of potential for use in remote Aboriginal communities is direct seeding in association with mechanical soil shaping. Direct seeding is a technique which is currently being enthusiastically promoted to pastoralists. It essentially refers to the establishment of vegetation through the distribution of seed. However, in degraded lands, particularly in the arid and semi-arid regions of Australia, vegetation establishment is much more likely to be successful if effort is also invested in soil preparation (Bastin 1991; Tatnell 1990).

For several decades now researchers in Australia have been investing effort into the development of soil preparation techniques that are not only capable of enabling seeds to germinate successfully but will also enable newly germinated vegetation to permanently re-establish itself (Cunningham 1987). In the arid and semi-arid regions of Australia, where water availability is the critical limiting factor, techniques which involve the moving and ripping of substantial amounts of soil to maximise rainfall catchment and improve the infiltration of water have proven to be the most effective. The soil shaping techniques that have been most widely used in Australia for this purpose are the construction of ponding banks, pits and furrows.

The concept of soil shaping can hardly be considered new. Earthworks to divert floodwaters and maximise use of rainfall have been used by ancient cultures for thousands of years. As early as 600 years B.C. a system was developed on the banks of the Nile to channel the regular floods into a series of rectangular basins bordered by dykes (Heathcote 1983).
The basic principle of soil shaping techniques is very simple. Water retaining structures such as pits, furrows, waterponds, and the Nile valley basins work because they enable water to successfully penetrate the hard soils of arid regions and become available to seeds and existing vegetation. They also enable wind-blown and water-borne organic matter and seed to collect, improving the soil and promoting natural regeneration.

PONDING BANKS

Ponding banks are usually constructed using a bulldozer or grader. The experience gained from the construction of ponding banks in pastoral regions in recent years suggests that the size and shape of the banks should be determined in response to the topography of the country. In flat, scalded country circular waterponds are recommended. Low horseshoe-shaped (concave) banks are recommended on land with a slope of < 0.15% and crescent-shaped banks on land with slope > 0.55% (Rhoades 1987). In steeper country (gradient > 2%) experience has shown that it is safer to build many short small banks with a flat or slightly convex shape, above or across erosion zones (Bastin 1991). It is also recommended that the height of the banks should be constructed so that, when settled, the bank is at least three times the depth of the ponded water. For example, if 10cm of water is to be ponded the bank should be built 40cm high which will, after weathering and compaction, reduce to a settled height of 30cm. The recommended maximum depth seems to vary. Recommended depths have been given as 7.5cm for the Hay district (Rhoades 1987), 15cm for the Broken Hill district (Newman 1966), 15cm for central Australia (Bastin 1991) and 6cm for the Carnarvon region (Williams and Shepherd 1991).

FURROWS

Furrows are typically constructed using an opposed disc plough. Commercially available opposed disc ploughs comprise of a ripper and two opposed discs mounted approximately 1m apart and at an angle of approximately 45 degrees to the direction of travel. The plough cuts two furrows and the soil is ripped approximately 300mm deep. The ridge formed is approximately 1m wide and from 350 - 400mm high depending on the setting of the plough (Keetch 1981). A seed box is mounted on top of the plough enabling the furrows to be sown as they are formed. The 300mm furrows are usually constructed so that they follow the contour of the land and are broken regularly (ie. they are not continuous) to prevent erosion from the channelling of run-off water. However, on flat ground, furrows are typically made in spiral patterns.

The establishment of vegetation in furrows from naturally sown seed is not uncommon (Keetch 1981; Last 1990).

PITS

Pits are commonly created by a Paech pitter-tiller machine. The pits are approximately 1.8m long, 380mm wide and 300mm deep at their deepest point (Keetch 1981). Like the opposed disc plough, pitting machines are usually fitted with a seed box and pitting and seeding occur simultaneously.
The Pitjantjatjara Council Landcare Service first experimented with ponding banks at Ernabella in 1972. The banks at Ernabella were constructed with the help of the Land Conservation Section of the Conservation Commission of the Northern Territory (CCNT) who had previously built a great deal of seeded ponding banks, pits and furrows to revegetate and stabilise dust around Alice Springs. Although the land ponded by the banks was intended to be revegetated through the planting of seedling bagstock, it was found that once the previously compacted soil was ripped and ponded (allowing effective infiltration of water) the seed that was already present in the soil, but previously unable to germinate, was then able to do so. Witchetty bush (Acacia kempeana) and Acacia bush (Acacia victoriae) naturally volunteered in the treated areas and these species are now well established on the site.

Inspired by this unintentional success and also by the work around Alice Springs and on Central Australian pastoral properties, deliberate attempts to rehabilitate degraded land using mechanical soil treatment and seed were attempted by the Pitjantjatjara Council Landcare Service in 1987.

The Pitjantjatjara Landcare Service determined that a very important part of revegetation in remote communities was the careful selection of appropriate community areas to be treated and the appropriate species to use. Effective community liaison was essential in order to gain an understanding of community functions and how they relate to vegetation and land use. This then enabled the identification of sections of land around the community that were least used by people. Soil shaping work and physical barriers to protect vegetation (fences, traffic bollards etc.) could be then be planned such that they would not be detrimental to the community's social functions. This was very important. Soil structures and physical barriers that are constructed in such a way that they substantially interfere with community functions are unlikely to be welcomed, accepted or even beneficial to the community.

An accurate assessment of the degree of soil degradation is also important. It was found that in some of the community spaces identified as appropriate for rehabilitation work, although the vegetation had been removed, soil degradation was minimal. In these areas it proved unnecessary to create pits, furrows, waterponding banks or even scatter seed. Once the persistent impact of people and vehicles on the vegetation was curtailed through the construction of fences and the re-definition of roads with controlling drains and traffic bollards, the vegetation would re-establish naturally. "An area of land was (just) fenced at Angatja, a homeland west of Amata, and the regeneration of acacia bush (Acacia victoriae) was substantial" (Last 1990).
In other areas, designated as culturally appropriate for revegetation, the soil degradation was substantial and mechanical soil shaping and seeding was deemed necessary. But which species would be the most appropriate to use?

Previously, most of the direct seeding work that had been performed by the Land Conservation branch of the CCNT had been directed at seeding plants that would effectively stabilise soil and provide feed for stock. The plants considered most suitable for this purpose were Buffel Grass (*Cenchrus ciliaris*), Birdwood (*C. setigerus*), Old Man Saltbush (*Atriplex nummularia*), Mitchell Grass (*Astrebla lappacea*), Native Saltbush of Israel (*Atriplex halimus*) and Northern Bluebush (*Chenopodium auricomum*). However, in remote Aboriginal communities, because of the need for trees and shrubs to supply shade, shelter, firewood, tools and artefacts it was decided that the seeds of larger shrubs and trees be used in addition to the seeds of grasses and small shrubs.

In 1987, using an opposed disc plough the Pitjantjatjara Council Landcare Service, the Land Conservation section of the CCNT, and the residents of Kalka, Piyalyatjara, Wingelina and Warakurna constructed seeded staggered furrows and spirals in each of these four communities. The results, after four years, are variable but nevertheless extremely encouraging. A small amount of rain (5-6mm) that fell in December 1987 was sufficient to germinate some of the grass and shrub seed that were planted. Follow up rain during the Autumn months of 1988 further assisted this growth. The success of the treatment was found to be significantly influenced by soil type. At Kalka, Piyalyatjara, and Warakurna, where the soils were lighter, only the grasses germinated along with a few Old Man Saltbush plants. However, at Wingelina, where the soil was heavier and the light rainfall was held by the soil more effectively, Witchetty Bush (*Acacia kempeana*), Umbrella bush (*Acacia ligulata*) germinated, in addition to the grass and saltbush species. More recently, self-sown Mulga trees (*Acacia aneura*) were also observed to be growing in the furrows and spirals.

In November 1990, the Pitjantjatjara Council Landcare received a grant from the NSCP to revegetate the bare land around the Warburton community. This time in addition to spirals and staggered furrows made with an opposed disc plough, ponding banks were also constructed using a grader. Smaller seed species were sown using the opposed disc plough with the attached seed hopper whilst larger seeded species such as Acacias were hand-sown by members of the community. Warburton received substantial falls of rain in May 1991 and many of the trees, shrubs and grasses that were planted have now germinated.

One of the issues the Pitjantjatjara Council Landcare Service has been confronted with in this work is the need for large quantities of local seed. It is recognised that revegetation programmes for communities and homelands need to include the establishment of stands of single species in order to provide a source of seed for future revegetation programmes.
The Walungurru community has also been involved in rehabilitating degraded land around their community with the assistance of Tangentyere Council and the CCNT. In February 1989, 10 appropriately selected hectares of land around the Walungurru community were treated with opposed disc ploughs. Through consultation with the community it became apparent that at Walungurru only locally occurring species were to be used. The people of Walungurru collected kilos of appropriate local seed for the revegetation programme, mainly Acacia and Eucalypt species. This seed was supplemented by purchased seed to make up a mixture of 23 native species. As with the work at Warburton, smaller seeds were sown using the seed hoppers and the larger seeds were hand-sown by community members.

The results of the work at Walungurru have also been impressive. After 2 years of growth, fed only by the scant and unreliable Western desert rainfall, ground cover and erosion control has been achieved and the resultant plant density closely resembles that of the natural shrubland surrounding the community (Hay 1991).

DIRECT SEEDING AND SOIL SHAPING TECHNOLOGY IN REMOTE ABORIGINAL SETTLEMENTS: THE FUTURE.

The experiences of Central Australian remote Aboriginal communities have elucidated many aspects of the use of direct seeding technology in remote communities that warrant further attention. Some of these issues are common to those raised by pastoralists. Issues such as: the possible benefits, cost effectiveness and social appropriateness of seed treatments such as pelletization and scarification; the potential role of fire management on revegetated areas (Purvis 1986; Friedel et al. 1990); the role ants and other insects play in seed dispersal and establishment (Greenslade 1987); and the need for seed orchards. Other issues are perhaps more specific to remote Aboriginal communities themselves. For example, if the desired goal of the revegetation programme of a remote Aboriginal community is the restoration of a vegetation community that will supply shade, shelter, firewood and food, as well as an environment that will attract game - how should furrows and ponding banks be constructed such that they best facilitate the achievement of this goal? Also: what is the most desirable arrangement of the furrows?; what is the optimum seed mix to use?; what sort of successional changes will the vegetation undergo once it is established and how will the composition of the initial seed mix influence this?; and is there a role for drip irrigation or regular manual irrigation in the seeded furrows?

There are a number of organisations that are presently looking into these sorts of issues. Many of them are concerned mainly with the issues of direct seeding and soil shaping as they relate to the pastoral industry, but some are specifically looking at the use of this technology in remote Aboriginal communities. The Pitjantjatjara Council Landcare Service and Tangentyere Landcare are continuing to follow up and expand their involvement in the dissemination and development of this technology in remote Aboriginal communities in Central
Australia. In W.A., the Remote Area Developments Group (RADG) is now conducting research into direct seeding and mechanical soil shaping for use in remote Aboriginal communities the Pilbara.

Clearly, there is still much to be learnt about the use of direct seeding and soil shaping techniques in Aboriginal communities but nevertheless, the present progress in Central Australia should not be ignored. Considering the extent of vegetation loss and soil degradation that is present in many remote Aboriginal settlements in Western Australia, surely this is a technology that the people of remote Aboriginal communities, and those that work with them, should seriously consider.

ACKNOWLEDGEMENTS

I would like to acknowledge Mr. Mike Last (Pitjantjatjara Council Landcare Service), Mr. Peter Hay (CCNT), Mr. Alan Harrison (Tangentyere Council Landcare) and Mr. Tony McDonald (Tangentyere Council Landcare) for their co-operation in providing much of the information discussed in this paper.

REFERENCES


COMPOSTING YOUR ORGANIC HOUSEHOLD WASTE

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Home composting can assist in improving hygiene in urban and remote communities and in efforts in community revegetation. Principles involved in home composting is described that can provide communities with the methodology and ensure correct operating procedure.

INTRODUCTION

One of the things that western society - and ours in particular, excels in is producing waste. We bury it in holes, burn it, dump it in oceans or build mountains out of it. The total waste production in Perth in 1991 will exceed one million tonnes. Over half a million tonnes is produced in the household. Approximately 70% or 350,000 tonnes of domestic waste is organic and can this be composted.

In a recent study commissioned by the State Government waste minimisation was identified as a priority and household composting is a very effective and appropriate method of reducing the waste stream.

Most of the environmental impact of landfills is caused by the decomposition of the organic waste fraction. The leaching of solubilised organic compounds is polluting and it also carries pollutants such as heavy metals into the groundwater table. During the decomposition of organic waste various polluting gases are released e.g. carbon dioxide (greenhouse), methane (ozone and greenhouse), ammonia (odour and acid rains) and hydrogen sulfide (odour), so more appropriate disposal of organic waste through composting is desirable. Landfill consumes land and approximately 500 hectares are currently restricted as a result of this.

On the opposing end of the environmental impact of landfill in Perth (Western Australia) there is the poor sandy soils of the Swan Coastal Plain. The sands are characterised by a low capacity to retain nutrients (fertilisers and moisture), have a very low organic matter and clay content and a low buffer capacity. To assist in improving the soils peat moss is imported from as far as Scandinavia, and is available on the market. There is a demand for soil organic matter in Perth such as a good compost.

Household composting results in a reduced (up to 50%) waste stream, reduced waste collection costs for the council and a good soil conditioner for gardens. A number of councils have already acknowledged these advantages and have made home composting bins available to ratepayers at subsidised rates.
HOME COMPOSTING

What is composting?

Composting is the process whereby organic matter is rapidly decomposed by a range of microorganisms using oxygen. During the process heat is released which speeds up the process and this also sanitised the material from pathogens and weed seeds and plant disease.

The complete composting process consists of four different stages.

Stage 1.: Incubation or mesophilic phase:
This stage lasts for ± 24 hours during which the organic matter is invaded by mesophilic composting organisms. These are organisms that thrive between 25°-45°C. They cause the temperature to rise in the composting material.

Stage 2: Thermophilic phase:
This is the "hot" period, during which organic matter is decomposed rapidly. The temperature can go up to 70°C in the heat core. However 55° is the optimum temperature. The oxygen demand is very high and thus needs to be supplied by regular turning (every 2-3 days). This phase lasts for 2-3 weeks depending on aeration.

Stage 3 Cooling Phase:
This phase sets in when there is insufficient organic substrate left to maintain the high temperature. The temperature will drop due to water evaporation and heat convection. When the temperature drops below 45°C mesophilic bacteria and other organisms will re-invade the fresh compost. This phase lasts for a few days.

Stage 4. Compost maturation phase.
The fresh compost needs to stabilise (mature) further, since fresh compost can be toxic and "too sharp" for plants. This is done by other organisms such as fungi, protozoa and actinomycetes who give the compost the fresh earthy smell. For this phase counts "the longer the better", though 3-4 weeks would be a minimum. Worms and insects also play an important role during maturation.

Properties of compost

Mature compost can improve the structure of sandy soils as well as heavy clay soils, by formation of soil aggregates. This will improve water retention capacity thus reducing irrigation requirements. Compost also improves the water absorption of sandy soils (wetting agent).

Compost contains a lot of nutrients (N,P,K) and trace elements (Ca, Mg etc) which are slowly released as the compost is broken down further. Compost can also absorb applied fertiliser and
release it slowly. This reduces fertiliser leaching into the groundwater table. During the composting process certain organic compounds and antibiotics are produced that prevent seed germination, giving compost the property to keep weeds down. If the composting process is done properly the compost will be free of pathogens, weed seeds and plant diseases. Compost is found to benefit plants growth and produce healthy vegetables, with more flavour than vegetables grown with solely synthetic fertilisers.

Requirements for composting to take place.

There are five requirements for composting to take place.
1. Organic matter
2. Moisture (40-60%)
3. Nutrients (C:N:P = 250:10:14)
4. Air (oxygen)
5. Microorganisms

It is important to mix the ingredients in the correct ratios, in order to produce a complete diet for the microorganisms. Too much carbon (paper, sawdust) will result in incomplete composting and the compost will exercise a demand on the nitrogen in the receiving soil. Too much nitrogen will result in loss through ammonia, causing odour and attraction of flies.

A correct combination of waste can be calculated from Table 2. A carbon to nitrogen ratio of between 20 or 30 to 1 is essential.

Table 2 Approximate composition of some organic waste materials

<table>
<thead>
<tr>
<th>Material</th>
<th>C/N ratio</th>
<th>% Moisture in material</th>
<th>g C/100 g moist material</th>
<th>g N/100 g moist material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lawn clippings</td>
<td>20</td>
<td>85</td>
<td>6</td>
<td>0.3</td>
</tr>
<tr>
<td>Weeds</td>
<td>19</td>
<td>85</td>
<td>6</td>
<td>0.3</td>
</tr>
<tr>
<td>Leaves</td>
<td>60</td>
<td>40</td>
<td>24</td>
<td>0.4</td>
</tr>
<tr>
<td>Paper</td>
<td>170</td>
<td>10</td>
<td>36</td>
<td>0.2</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>35</td>
<td>80</td>
<td>8</td>
<td>0.2</td>
</tr>
<tr>
<td>Food waste</td>
<td>15</td>
<td>80</td>
<td>8</td>
<td>0.5</td>
</tr>
<tr>
<td>Sawdust</td>
<td>450</td>
<td>15</td>
<td>34</td>
<td>0.08</td>
</tr>
<tr>
<td>Chicken manure</td>
<td>7</td>
<td>20</td>
<td>30</td>
<td>4.3</td>
</tr>
<tr>
<td>Chicken litter</td>
<td>10</td>
<td>30</td>
<td>25</td>
<td>2.5</td>
</tr>
<tr>
<td>Straw</td>
<td>100</td>
<td>10</td>
<td>36</td>
<td>0.4</td>
</tr>
<tr>
<td>Cattle droppings</td>
<td>12</td>
<td>50</td>
<td>20</td>
<td>1.7</td>
</tr>
<tr>
<td>Human urine</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.9 g/100 ml</td>
</tr>
</tbody>
</table>

Calculation example: Lawn clippings : food waste : paper = 4 : 2 : 1
Carbon/Nitrogen ratio: \[
\mathcal{F}(C,N) = \mathcal{F}(4 \times 6) + (2 \times 8) + (1 \times 36), (4 \times 0.3) + (2 \times 0.5) + (1 \times 0.2)
\] = 27.5

The smaller the particles, the quicker the composting will proceed. Garden prunings and branches may have to be shredded. A small shredder may be a useful investment depending on the compost requirement. When the combination is correct the microorganisms will come by themselves. The moisture content is also important to keep an eye on, as too much moisture prevents air from entering resulting in a stinking mass and too dry will reduce the activity of the microorganisms.

Trouble Shooting

There are four main causes for a failing compost heap.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Too dry</td>
<td>Add water, or moist organic matter (grass, food)</td>
</tr>
<tr>
<td>Insufficient temperature</td>
<td></td>
</tr>
<tr>
<td>2. Too wet</td>
<td>Add dry organic matter such as sawdust or paper (rotting)</td>
</tr>
<tr>
<td>low temperature, bad odour</td>
<td></td>
</tr>
<tr>
<td>3. Carbon:Nitrogen too high</td>
<td>Add high nitrogen waste, eg grass composting before stopping, with correct moisture content and no foul odour.</td>
</tr>
<tr>
<td>Indicated by short time clippings, manure</td>
<td></td>
</tr>
<tr>
<td>4. Lack of other nutrients</td>
<td>Add bone meal or rock phosphate. (phorphorus !)</td>
</tr>
<tr>
<td>Low temperature</td>
<td></td>
</tr>
</tbody>
</table>

Methods

Of all the available techniques available, the compost heap seems to work best if sufficient waste is available to produce a minimum size heap of 1 to 2 cubic meter. This size is required to insulate the inner heat core, so that sufficiently high temperatures can be achieved.

Compost bins and the various other constructions are more suitable for small households. Examples of different methods are the Indore, Berseley and New Zealand systems. Construction designs of these and a number of others are described and evaluated in the referred literature list at the end, particularly useful is the 'Rodale Guide to Composting'. They require some investment of money and generally don't function better than a heap, but work with less organic matter input. In enclosed bins the compost has a tendency to become too moist due to a lack of water evaporation. A few tools for composting are gypsum, as it contains much calcium, which makes compost firmer and reduces ammonia emission and thus flies. Seaweed is good for the supply of nitrogen and trace elements. Fly problems can also be reduced by planting fly repelling plants such as citronella and marigolds and calendula. Composting of various wastes is very much open to experimentation.
by the individual and as long as the basic rules are respected, success should follow.

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REMOTE AREA COMMUNICATIONS

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Australian urban centres have a highly advanced communications network. Yet remote communities and pastoral stations in Australia depend on a system which is less modern and developed in an ad hoc manner. With frequent failure or shortage of communications equipment the movement of the people around remote areas is endangering lives. This paper discusses existing options for remote systems and proposes the outline of a remote network.

INTRODUCTION

In many countries the size of Australia, the ability to extend and provide new communications services to remote areas is restricted by the impracticality and high cost of using conventional technology to reach remote or dispersed populations. In 1984 the Report of the Task Force on Aboriginal and Islander Broadcasting and Communications was published. This report proposed a sophisticated two-way communication system based on the Canadian experience, to service remote areas and particularly indigenous communities in remote areas.

As the report pointed out, broadcasting systems were already advanced, with many remote Aboriginal communities having equipment to receive and re-broadcast programs. This system gave them the freedom to insert alternative local programs or program tapes from CAAMA or any of the other large regional stations.

This development has been important for the cultural integrity of Aboriginal people, and has supported the Homeland Movement. However such policy for appropriate planning has not been developed for two-way communications.

It is not possible to identify a communications policy in Australia. In practice, in communications, an elite or informal college of policy makers exists, drawn from political parties, the bureaucracy, commercial interests, activist groups and individuals, the media and academics. .. Much decision making, or lack of it, within the elite does not attract public attention although it may be of profound significance.

Even with the publication of the Task Force Report in 1984, and the acknowledgement that Telecom was committed to provide telephone communication to remote areas by 1990, we are now looking at most areas being linked in by 1994. Much of the advice presented in the report still holds true. They proposed a sophisticated system based on satellite links. However, the
earth station equipment proposed in this report has not been developed as cheaply as it was hoped at the time of the report.

However, there is one important point made, It would not be necessary to establish a network which satisfied Telecom interface requirements, but rather it would be feasible to arrange for a capability to interface with the Telecom network at a particular node or nodes in a similar manner as now occurs with OTC and the Royal Flying Doctor Service high frequency radio network.

In fact radio-telephone interconnects are now generally used by people working in remote areas. Also further sophistications, such as select call which provides the user with call codes for different contacts, have been developed. It is probably because there is a large business and public service market in remote areas, that such progress has been made.

PROPOSED SYSTEMS

To plan future developments, the present systems should be examined for the suitability of extending or adapting them to remote areas, and whether they satisfy the needs of the communities. While mobile systems are more flexible, fixed Telecom systems are a cost that should be supported by the whole community, while individual communities through ATSIC have to pay for their own radios and licences.

Fixed systems

The Western Deserts Homeland Movement in 1984 recommended that hand pumps be placed at regular intervals along roadways. Telecom has recently proposed instead that telephones be installed at regular intervals, for example one could be placed on each microwave repeater link on the existing telephone networks. Such systems provide a good emergency backup service, if maintenance is arranged on equipment that is not regularly used and is located in isolated areas. In fact maintenance of Telecom equipment is not as difficult as it sounds. The coded signal transmitted from each Telecom repeater includes information about its state, and that of the repeaters further up the line.

The Telecom network is slow in being extended to remote areas, but they stipulate some guarantee of permanency of a settlement before they will extend services to a community. That is there must be some proof of long term lease or ownership of the land, which many Aboriginal groups have not yet achieved in most areas. This requirement is because of the cost of the system is high and it takes time to get the equipment organised and out to the area.

Also once a Telecom telephone to telephone link system is set up, further expansion of that system may not be possible. These links are just a coded form of the voice which is transmitted by microwave, copper wire or optical fibre. Then a second link would have to be laid, which is not cost effective. A more
concentrated link system, which will enable greater expansion and hence the link to an area is not likely to "fill up", is being developed for Telecom.

While telephones provide a convenient means of communication, the voice is converted to code for transmission. In the Telecom network, the code must be suitable for long distance transmission, and for connecting to other lines, at the exchanges. This coding equipment is costly. The other option is that discussed before, where an area can be inter-linked by telephones but separate from the general network. Telecom regulations allow such "common interest group" to operate and share their own communications systems, which will be independent of the main network, but can link in at a node or nodes.

Radio-telephone interconnects are a very simple form of such a system. If operating a radio linked to such an interconnect, the radio call is made direct to the base station which is also connected to the telephone system. An electronic coding box receives the radio signal and converts it to the correct code for transmission down the Telecom line. This communication is two-way.

Satellite Systems

With the development of satellite technology at least one trial system has been set up in Aboriginal communities. The Q-Net was organised by the Queensland Government through the Health Department. The AUSSAT satellite was used to connect two-way earth stations at all towns in the Gulf of Carpentaria. Mount Isa Base Hospital provided the central pin of a star shaped network.

The system showed improvement particularly in reliability of communication. Radio calls can frequently be poor due to interference by hills or varying climatic conditions such as storms or cloud cover, thus communication is hindered. One thing the report on this system noted is that the introduction of the technology resulted in financial savings to the health service, with the increased efficiency and more rapid response to emergency.

Such systems are being installed for large companies, but the cost may not be feasible for the present need for rapid upgrading. Yet such a trial is an important step in efforts to lobby government for better services in remote areas.

Mobile Systems

Mobilenet

This is the newest communications system under development, which connects mobile telephone by microwave to satellite base stations. Microwave transmitters have a secure range of about 40km so there must be regular repeaters setup, or the telephone user must be close to the base station. The base stations
transmit to the Telecom system by satellites which provide wide coverage and reliability. However satellite services are generally focussing on the lucrative urban business market where there will be a small distance between the user and the base station.

Radio

High Frequency (HF) radio communication is already used widely by remote communities and vehicles, either radio to radio or through the Royal Flying Doctor Service (RFDS) system. At the RFDS stations messages can be left for other callers, or sometimes there are connections to the phone system. In some communities the radios can call into a fixed base system or even their own radio to phone interconnect. This radio network is used by communities to keep regularly informed of each other's movements and can be used as an emergency system if people do not call in at pre-arranged times. However this can lead to false alarms, and more training is needed in correct equipment usage and maintenance. For instance, people must remember to radio in each trip they make.

The radio system in Australia has been introduced without planning. This is particularly important in terms of the allocation of frequency licences. These may not match community boundaries and hence not match the needs of Aboriginal communities.

Flexible systems

A combination of radio and telephones would provide both the mobility and ease of installation of radio systems, and the security of telephone systems.

As mentioned above, much new equipment exists for connecting radio calls to the telephone system. This enables the radio to substitute for the telephone until Telecom installs a suitable system in the area. Such interconnects are cheaper than a complete Telecom installation but still require a large injection of funds into the region.

Emergency Only

Radio

The emergency back up system by radio is through the RFDS. The RFDS stations are not staffed for 24 hours for two-way communication, or telephone interconnect. However radios can have fitted an RFDS emergency tone call encoder so that when the local base is unstaffed the tone will be received automatically and retransmitted to the central RFDS base in Perth.

Beacons

At present one way communications systems, or beacons, have only been developed for aviation and shipping systems and may not be compatible with the land network. The beacon is switched
on in an emergency and the position of the beacon can be
determined by two ground bases, or satellite. However this one
way system can create unnecessary rescue work if for example the
problem is a shortage of petrol or water which could be supplied
from a nearby community.

FUTURE DEVELOPMENTS

Radio is clearly the basic option for remote areas, but how it
is used and developed is the issue. It has been found that the
points to consider in developing a communications systems are:
* Durable equipment should be developed to overcome any common
breakage problems.
* The existing system should be rationalized in terms of
frequency allocation.
* Training in usage and maintenance of the radio should be done
thoroughly in all remote communities.
A network should be developed similar to that used at present
through RFDS bases, but decentralised and based around regional
community centres. This would place responsibility for safety in
the hands of the Aboriginal people who know each other's habits.
* A backup to any radio system is necessary at least for
emergency situations.
* Any development must plan towards future linking of remote
areas into the Telecom network.

APPROPRIATE TECHNOLOGY

As a group RADG is involved in developing appropriate technology
for remote areas, and particularly suitable to the culture and
lifestyle of Aboriginal people. In terms of communication this
need arises in two areas.

Firstly the equipment available is often not durable enough for
the climate and social environment in which it must be used.
Particularly problems have been expressed with radio
microphones which tend to malfunction frequently.

Secondly the network or call system must be developed to match
the movement of the people, and their needs. For example if
party lines are more useful than many individual community lines
in one area, licences should be granted for single frequencies
covering a large area. Thus members of the community could move
around a wide area and always have a chance of connecting with
another radio operator on that frequency.

Part of any such network would also be ensuring that any
emergency or general-use frequency is monitored at all times.
This could be done through recording systems at fixed base
stations, or rosters.

MAINTENANCE AND REPAIR

As was stressed in the Peter Alexander report, any development
of a communication system will require training in various
areas:
* usage patterns such as regular logging of trips to a central base
* regular maintenance work must be done on equipment, so most members of the community must be trained in basic maintenance.
* repair work would need to be carried out as quickly as possible, so members of the community should be trained as technicians for radio and telephone. Telecom will also be involved in such programs, which would be developed at places like Pundulmurra College (South Hedland) and Kalgoorlie College.

CONCLUSION

While radio based communication is not entirely satisfactory given the advanced state of Telecom systems in Australia, the issue of the large land area to be covered is clearly a problem. Unless simplified telephone systems are used as a temporary measure, the High Frequency radio is the most feasible remote area communication available. For security however there should be backup system such as regularly spaced telephones along roadways. The issue will be which government department will fund this...

REFERENCES

4. Ditto. p 82
5. Ditto p 82 gives full definition of "common interest group" as an avenue for development of networks uniquely suited to remote and/or Aboriginal communities.
APPROPRIATE TECHNOLOGY FOR ABORIGINAL ENTERPRISE DEVELOPMENT

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RADG has been developing appropriate health technology for use in remote communities in Australia. The greatest need for these technologies has been in Aboriginal communities. In developing appropriate technical artifacts, RADG has confronted two problems. Firstly we require good contact with remote communities for consultation and feedback. Secondly, in the production of artifacts appropriate for underdeveloped countries or regions, there is the need to include employment and self-determination as part of the benefits of a technology. These issues are discussed in reference to case studies in Australia and overseas.

INTRODUCTION

RADG has developed various technologies appropriate for use in remote Australian communities. In some cases these have been tested already in Aboriginal communities. In particular, the Remote Area Hygiene Facility (RAHF) has met an immediate demand for ablution facilities. This unit has been built in Kalgoorlie and Newman fringe dweller camps, and in Halls Creek.

Through this process, RADG has developed some concept of appropriate methods of introducing technology to Aboriginal communities and gaining feedback to improve what is developed. In the long term we realise we need data on the effect on the health of the camps when these facilities are set up. This assists Aboriginal communities in deciding whether the ablution facility is worth investing in, and improves the chance of obtaining government funding for further unit construction.

The construction of the RAHF has been generally on-site, and involved Aboriginal labour. Those who wish to work on construction and who do not have the required skills are trained through the local TAFE, for example in welding and metal work. After they have built one or two units, the people generally understand the design and can continue to build more units for new camps or outstations which are set up in the area. Also, most importantly, if any item in the facility breaks down, there are people on hand in the community who can perform minor repairs rather than the people becoming frustrated with technology that never works.

Since these first constructions we have began developing changes to the design, as proposed by the communities. It is hoped that the pride developed in building their own facilities will encourage the community to care for the equipment. In the long run the income generated from using skills from the community, and eventually setting up an Aboriginal construction company,
will increase moves towards self-determination of the Aboriginal people of Australia.

EXISTING ENTERPRISES

Aboriginal people have been setting up their own enterprises at least since 1948 when Northern Development and Mining was formed by the Western Desert Aboriginal people. This was part of a long fight for better conditions which became known as the Pindan movement and attracted support form as far south as Jigalong.

Many Lands Councils and Aboriginal Organisations are now funding and organising the setting up of enterprise schemes. Most are in the area of farming, horticulture, arts and crafts or tourism. Some are in skilled or semi-skilled trades such as glass work in Kalgoorlie and metal work at the Centre for Appropriate Technology in Alice Springs.

All such enterprises also involve skills in management and accounting, which more and more Aboriginal people are training to do. Also the Aboriginal Enterprise Company has set up a computer accounting system for use in community stores. The program stock takes and assists in the management of the store. Information from each store is networked to the Perth office of the Aboriginal Enterprise Company where analysis can be done and advise given on future ordering for the store. Also this enterprise involves training. The store program has a tutorial so that new people can learn how to manage the store computer system while staying in their community.

Thus there are now a growing number of options for Aboriginal people to develop enterprises that give the opportunity for income to the community and training of Aboriginal people for a wide range of jobs.

ISSUES IN ENTERPRISE DEVELOPMENT

Little information is available on the type of enterprises being developed by Aboriginal people in Australia. Jill Byrnes from the Rural Development Centre, University of New England (NSW) ran a national survey of Aboriginal enterprises in 1988/9. In studying enterprises she developed an outline of what issues were important to Aboriginal people when starting up enterprises.

The issues which Jill Byrnes studied for each enterprise structure were:
* the objectives of the owners in starting the business. The commercial or economic objective may be very much secondary to social or community objectives.
* the achievements of the enterprise and its progress judged according to these objectives.
* the type of funding support used to start the enterprise and run the business until it is independant.
* The differences found between government policy and action in relation to this funding support.
* the legal structure of the enterprise, such as whether it is a partnership, co-operative, company.

66
decision making structure, which is particularly an issue if Aboriginals are not managing the enterprise.
The employment of Aboriginal and non-Aboriginal people.

In relation to training and skills Jill Byrnes considered:
* strengths, skills and resources that were available to start the enterprise
* the skills needed to run enterprises
* skills being developed while the enterprise is running
* support for the enterprise in terms of finance, training or community support
* support required which is not available.

Such studies are important as reference for starting any further enterprise, as it prevents the same mistakes being made again, and provides positive examples of successful enterprises. These case studies are a rare source of information on generating self-supporting enterprises or enterprise that provide social benefits to the community.

OVERSEAS EXAMPLES

Aboriginal groups in the Americas have been struggling with a similar situation of cultural domination and economic oppression. Jill Byrnes also studied economic developments in indigenous communities in Canada. Also little material is available in Australia on Indigenous enterprises in the US, the situation on the Navaho Lands is exceptional, and provides an interesting example.

Canadian Aboriginal Enterprises

The Canadian Aboriginal Economic Development Strategy (CAEDS) was introduced by the government in September 1989. The strategy focuses on long term planning and co-ordination between relevant government departments, Aboriginal business and community leaders, provincial (state) governments and the Canadian business community in general. It is federally co-ordinated by the Canadian government.

This strategy resulted from a review of the opportunities and constraints on economic development for Aboriginal people, which are:
* shortage of capital and credit
* lack of education and access to training
* lack of employment experience
* ignorance of government assistance program
* racist stereotypes of Aboriginal people by banks, employers etc.
* complex legal regulations that are designed for urban enterprises and are unnecessary in remote settings.

The strategy attempts to reverse these situations. It also incorporates a research and advocacy system to provide continuously updated data to the public, governments and Aboriginal organisations about the performance and progress of enterprises. Also it is a means of spreading innovative ideas.
and information on new business opportunities, business services and support networks.

It is hoped that this process may prevent the problem that exists in Australia where data on the performance of Aboriginal businesses is not generally available and myths and uncertainties breed.

The Canadian Aboriginal Economic Development Strategy is based on the premise that "Only when Aboriginal people play a significant role in decision-making on program operations are Aboriginal concerns and sensitivities taken into account" (Government of Canada, 1989, 15).

This is in contrast to the Australian Government policy which is concerned with enabling Aboriginal people "to achieve broad equity with other Australians in terms of employment and economic status" (Australian Government 1987, Policy P1, 3). Bruce Walker has pointed out that equity "is at variance with the concept of Aboriginal self-determination, unless Aboriginal people choose to adopt a totally western European lifestyle, or vise versa"

Also an appropriate program of training has been developed in Canada through Native learning centres. Computer programs are used to enable students to have access to all areas of knowledge in their local area, without moving to a large urban centre. Also learning can be at the student's own rate.

Some work has been done in Australia in teaching literacy and numeracy to people from a culture that is very different to the western European culture that devised these skills. Often the concepts assumed in these subjects are foreign to the Aboriginal way of understanding. Any strong training program that is developed in Australia for involving Aboriginal people in semi-technical or technical jobs, will have to consider the ideas developed by such studies.

Navaho Nation

The Navaho people have secure land tenure of a large area covering part of Arizona, New Mexico and Utah. This area began as a small area ceded by the US government as a result of the treaty signed with the Navaho people after the US civil war. Since then more land has been purchased by the Navaho people.

On this land many enterprises are run, often in partnership with non-Aboriginal firms outside the Navaho nation. One area in which the people work is in electronics. Most of this work is apparently component insertion on electronics boards and is done for the defence department. The Navaho involvement in defence electronics began during the second world war when Navaho translators were used in sending code as the Japanese could not decode messages in a language structure which they were not familiar with.
Thus some of the Navaho community have maintained some contact with the technology and ideas of computing, electronics and coding. Also the non-Aboriginal community has gained some advantages from the Navajo world view. The example of a technically skilled employment for the Aboriginal people of the US provides encouragement for development of enterprises that enable Australian Aboriginal technical skills and understanding to develop, but hopefully create an alternative perspective to technology to the dominant western European concepts.

DEVELOPMENT OF ABORIGINAL ENTERPRISES

RADG is going to assist the development of Aboriginal enterprises in Australia, some sort of process of assessing the appropriateness of such a process is important. There are various aspects of the enterprise, developed from Jill Byrnes' research, which must be considered:

* cultural aspect - the effect of the enterprise on the culture of the community and the surrounding environment.
* technical aspect - the level of technical skills that can be achieved by the people in the short and the long term and the technical skills that are relevant to their life.
* economic aspect - funds which are required, the market that exists for the product of the enterprise and hence the products to be made. For instance the product may be sold all over Australia and the community mainly benefit from funds, or the main output of the enterprise may be in social benefits to the community.
* organisational aspect - the enterprise can be under community control, or just part of the community, and the people must be represented in some way.
* training aspect - the previous experience that exists with technology and what sort of technology. Theories of cross-cultural education can be used to assist in training.
* interface - the enterprise will relate in various ways to the non-Aboriginal community and some amount of non-Aboriginal skills will be required.

By considering these aspects a framework will develop for ensuring to some extent that the enterprise which evolves is appropriate and of use to the community.

CONCLUSION

RADG is extending its technology research to look at enterprise development. It is felt that such a focus is important as part of developing appropriate technology artifacts for remote communities. Also it will require development of a fuller understanding of what is appropriate for Aboriginal people in Australia.
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2 Jill Byrnes. (1989) Enterprises in Aboriginal Australia: Fifty Case Studies Rural Development Centre
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A LOW MAINTENANCE, LOW WATER USE TOILET FLUSHING SYSTEM

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The development of an appropriate toilet for remote communities has taken many stages. The last feedback on the RADG toilet has been requests for a flushing toilet using a low water volume.

INTRODUCTION

There is little doubt that the common dry pit toilet is the best option for remote communities if the only criteria are low cost, low maintenance and low water use. The ventilation improved pit toilet (VIP) or its derivatives offer privacy, while limiting odours and flies. They are, however, dark and lacking a little in comfort. The pour flush toilet, because it incorporates a water seal, allows the toilet to be bright and airy while still eliminating odours and flies. They are also extremely difficult to block. While not strictly a dry pit, flushing only requires two litres so the life of the pit is not unduly affected. While the pour flush system has been used successfully overseas, and would probably be welcomed in parks or camps, it has become clear that permanent communities prefer the convenience and amenity of a push-button cistern.

These are however, designed for the vast majority of Australians who live in the large cities and not for remote communities. They require frequent parts replacement, are easily damaged and can be inappropriately adjusted. At best they use a 5 or 10 litre flush. At worst they run continuously, flooding the pit or leach drains. Not only does this excessive water use render the toilet flushing inefficient, it also has to be paid for by the community.

The Remote Area Developments Group (RADG) were asked to develop an appropriate flushing system that could be used in conjunction with the current pour-flush bowl and which would deliver the same 2 litres per flush.

PROTOTYPE DEVELOPMENT

If the new cistern was to be completely maintenance free, it was apparent that the ball-cock had to be eliminated. This was achieved by completely sealing the cistern. The cistern then became an accumulator (see Figure). The mains water enters the cistern after flushing and compresses the layer of air above it. The inflow of water ceases when the air is compressed to mains pressure thereby balancing the pressure of the mains supply. A non-return valve prevents backflow to the mains if mains pressure should drop for some reason.

The by-product of this simplified arrangement is that at flushing, the air is free to expand again and so the flush is delivered at mains pressure through the 32mm pipe connection to the pan. The force at which it delivers more than compensates for the small volume. It is ideally suited to the pour-flush
The only moving part of the whole system is the main flushing valve. Unlike the standard push-button cistern which only has to open against atmospheric pressure, the new valve has to open against 3, 4 or even 5 atmospheres pressure. Options tried for this have included a lever operated ball valve, which is difficult to make self-closing, and a push-pull gate valve which only requires the insertion of a spring to make it self-closing. If the numbers produced were sufficient, a manufacturer could easily adapt his mould so that it flushed on pushing in instead of pulling out, so it would be more difficult to damage. The longer term option would be a ceramic gate valve, so that only a light spring would be required to close the valve and the unit itself would last a lifetime.

The whole unit is assembled from class 9 UPVC pipe which can be glued together by semi-skilled workers and so suits decentralised production. A computer program is available to assess the size requirement for particular mains pressures and flushing requirements and will also be available in table form if required. Consultation with RADG is, of course always available for each new project.

The new cistern is adaptable to installation behind or in walls, having only the button visible if desired. As the accumulator can be installed anywhere not too far from the pan, it can be tailored to any installation requirement, even on the roof if only the pipe is desired inside the toilet.

SUMMARY

The new power-flusher is a low cost, low water use cistern with only one moving part that can be tailored to suit any architectural arrangement, even completely concealed within the wall. It can be made in any size without significantly altering the cost as no retooling is required. It can be made by semi-skilled workers from UPVC pipe which is extremely corrosion resistant and long lasting. It can be made for under $50 and should meet WAWA requirements.
Cross-sectional view of the RADG Power Flusher showing the unit full of water and the layer of compressed air trapped above.