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Debate

Is artificial acceptable? Can artificial recharge of aquifers help address water scarcity?

Dr Gideon Tredoux, CSIR

Artificial recharge is the process whereby surface water is transferred underground to be stored in an aquifer. The most common methods involve injecting water into boreholes and transferring it into spreading basins where it infiltrates the sub-surface. Underground water storage claims to be efficient because it is not vulnerable to evaporation losses and it is relatively safe from contamination. Can artificial recharge contribute significantly to maximising the use and sustainability of available water resources in South Africa?

The Department of Water affairs & Forestry (DWAF), in co-operation with the Water Research Commission (WRC), has completed the Artificial Recharge Strategy for South Africa. The vision of the strategy is “To use natural sub-surface storage as part of integrated water Resource management wherever technologically, economically, environmentally and socially feasible”.

Is aquifer recharge widely used in South Africa? Is it a workable and desirable solution to our water scarcity? *Water Sewage & Effluent* spoke to industry role players.

Appropriate conditions

Dr Ricky Murray, Groundwater Africa

Where conditions are favourable for implementing artificial recharge, it would be foolish not to do so. It would be like choosing not to divert water into a dam to keep it as full as possible even if conditions were favourable for doing so. The key question is not whether or not artificial recharge should be practiced but rather when is it appropriate to do so. This depends on a number of factors – key among these is the availability of a suitable water source, the ability of the aquifer to receive the water, the cost of implementation and operation, and management/skills requirements. In some cases, water quality is a problem but this usually translates into an economic factor.

Regarding water availability, the town of Atlantis (near Cape Town), where artificial recharge has been practised for more than 20 years, uses treated wastewater to recharge a sandy aquifer. This happens year round as the source water is perennial. Karkams, a small town in Namaqualand, however, practises opportunistic artificial recharge as rainfall is so irregular in that part of the country. Other towns, such as Plettenberg Bay, are considering recharging only in winter when there is surplus source water. Regarding aquifer suitability, not all aquifers have space at the right time to receive water. Many fill up naturally when there's water available for artificial recharge. Artificial recharge is usually a fraction of the cost of other options and it can be implemented incrementally to save on huge initial capital outlays. All artificial recharge schemes require management – one of the key factors being to ensure only planned water quality is transferred underground.

Official strategy

Fanus Fourie, Department of Water Affairs & Forestry

The Department of Water Affairs & Forestry (DWAF) developed a strategy to inform decision-makers and water-resource managers about artificial recharge and to take them through a process of incorporating artificial recharge in water-resource planning.

Not a lot of people know about the solution that artificial recharge can provide: improving water quality, natural storage ("water banking"), reducing land subsidence, saving water from evaporation, and maintaining the reserve – just to name five. Artificial recharge has a part to play in integrated water-resource management. Using surplus surface water run-off or evaporating sewage water that was lost to us and adding it to our scarce water resource as a new source. The cost of implementing an artificial recharge scheme could start from as little as R3 000 in the case of the town of Williston but, for a town like Lephalale, it could cost in the order of R4-million. DWAF is busy rolling out the Artificial Recharge Strategy for South Africa and the first step to the success is raising awareness.

Optimise resources

Gerhard Steenekamp, Clean Stream Groundwater Services

Groundwater is by far the most significant remaining fresh-water resource in South Africa. Active management and enhancement of groundwater quality and quantity should thus receive the highest possible priority. Artificial recharge is one of the most common and cost-effective methods to enhance groundwater quantity and optimise

the aquifer as a source of water supply – either emergency source, supplementary, primary source or a combination.
Although by far the majority of aquifers in South Africa are of the secondary, fractured rock type with limited storage ability, there is still tremendous opportunity to use aquifers for artificial recharge.
Active management and monitoring by competent people are obvious prerequisites for success of aquifer-recharge projects, especially in terms of quality of the source used for the recharge. Damage to the aquifer quality and physical properties is possible if strict control is not maintained, and damages resulting from improper management could be more costly than the savings realised from lower capital cost to establish an aquifer-recharge project.
Another aspect related to aquifer recharge is the storage of water in suitable underground mining areas. There are huge void volumes in a number of mining areas and the opportunity for underground storage of water in mining areas where reserves have been depleted increases by the day. As with the aquifer, mines will also vary in terms of suitability, especially in terms of quality.

Research under way

Dr Gideon Tredoux, CSIR

Decades ago, research found that water resources of South Africa could, at maximum, sustain a population of 80-million. This is based on the assumption that all water resources are used optimally. We are gradually approaching the point where there is insufficient fresh water in many areas and water re-use is becoming more and more important. Surplus surface water and purified wastewater are seen as the main sources of water for artificial groundwater recharge.
Windhoek is the only city in the world that directly recycles water. In 2008, it will be 40 years since it was introduced and, with a number of upgrades, the system is still alive and well. However, elsewhere in the world, indirect recycling via artificial groundwater recharge is the norm.
Recycling of wastewater via artificial groundwater recharge is being studied in a large EU project with eight study sites all over the world, including Atlantis in the Western Cape. Water-quality and health-risk assessment are key issues for this project and considerable attention is being paid to the removal of pollutants at very low levels, for example micro-organisms, pharmaceuticals and other constituents that may survive the treatment processes.

Proper management

Piet du Pisani, City of Windhoek, Namibia

The natural recharge of the Windhoek aquifer could not cope with the unnatural or even supernatural growth in population. Since 1990 the population has grown from 140 000 to more than 300 000 people but the average natural recharge of the aquifer has remained more or less constant at what is 12,5% of the annual consumption of the city.

In Namibia, the three dams serving Windhoek and the central areas lose, on average, 3,4 m per annum to evaporation. In the Windhoek aquifer, research over 10 years has proven that the aquifer represents a bank where water can be safely stored with minimal loss for the proverbial “non-rainy day”. When the aquifer has been replenished and can be replenished, the city would be able to survive for two or more seasons if the dams are dry.

Proper management is essential. The aquifer has to be a contained structure so that recharged water is not simply lost. Quality is paramount. Pollution of a fractured hard-rock aquifer is, for all intents and purposes, irreversible.

Cost-efficient

Phillip Ravenscroft, Maluti GSM Consulting Engineers

Artificial recharge of groundwater is an alternative to surface storage of water that warrants consideration at local and regional bulk scale. It is important to recognise that artificial recharge cannot create additional water resources but it can provide cost-effective storage of surplus water and, thereby, increase the overall yield from the resource.

There are growing concerns about the costs of building large dams – not just the financial return on the investment but also the significant social and environmental costs. While many alternatives have been considered in the past, artificial recharge of groundwater has never been investigated as a viable alternative on any large scale. The advantages of artificial recharge over the construction of surface storage would be significant, including reduced evaporation, lower financial costs, less environmental damage and it would exclude the social, environmental and economic repercussions of land loss associated with dams.

Viable alternative

Phillip Ravenscroft, Maluti GSM Consulting Engineers

Over much of South Africa, we have low permeability and low borehole yields. However, in areas of good borehole yields, groundwater is often over-exploited with negative effects on the resource, including reduced water quality and dropping water

levels. Artificial recharge could be an effective strategy for mitigation of these effects in impacted areas. We can then move from exploiting our aquifers until almost empty to managing them at “almost full” with water available when we really need it during drought years.

Obviously there are constraints. Conditions suitable for artificial recharge are not widespread and there are numerous criteria to meet for a successful scheme. The development of a scheme (and even the operation of the scheme) needs a team with a wide range of expertise and we do not have many professionals experienced in artificial recharge in South Africa. Ill-conceived and badly-planned artificial recharge schemes could damage aquifers or contaminate groundwater with long-term consequences. Fortunately our laws recognise this risk and, under the National Water Act of 1998, recharging of groundwater is a controlled activity that requires authorisation from the Department of Water Affairs & Forestry.

Worldwide application

Dr Shafick Adams, Water Research Commission

Artificial recharge is used as a management option in many parts of the world. In the US, by 1983, they had three operational aquifer recharge schemes and, by 2005, they had 72 systems in operation. In Southern Africa, we have a few recharge schemes that are considered successful: the two largest are the Atlantis and Windhoek schemes. “Artificial recharge” is only one of a variety of terms used to describe the process of transferring available surface water to the sub-surface and, more specifically, to an aquifer. The term artificial recharge is not widely accepted because the word “artificial” has the synonyms “fake”, “not real”, “synthetic”, “man-made" and “non-natural”, among others. Although not completely incorrect, these synonyms do not often bring to mind positive emotions. Other accepted terms include “managed aquifer recharge” (my term of preference), “managed underground storage of recoverable water” and “aquifer storage and recovery”.

The Water Research Commission has provided funding and research direction to assess the feasibility of recharging southern African aquifers with excess surface water. Through our research, the required research capacities (human and institutional) were developed within the water sector. We focused particularly on recharging secondary aquifer systems and South Africa is one of the leaders in this. Although managed aquifer recharge is practised worldwide and the technology is being developed at a steady pace, South African conditions do not always make it possible to borrow approaches from other countries.

Local conditions

Dr Shafick Adams, Water Research Commission

The fact that South Africa has, in most instances, a complex structural and mineralogical (hydro)geological environment makes it unacceptable to develop recharging schemes without proper research. Each potential recharge scheme will have to be thoroughly characterised, monitored and modelled to assess its suitability for receiving re-routed surface water. In addition, the recharging water needs to be of an acceptable quality to prevent aquifer clogging and undesirable chemical reactions that could mobilise harmful substances. This often requires a pre-treatment stage before recharging the water through infiltration basins, unsaturated-zone recharge boreholes and direct-recharge boreholes. If well-managed, managed aquifer recharge can be a valuable strategy for storing recoverable water as part of a larger water-management strategy. It is recommended that multidisciplinary teams are responsible for the development of these schemes. The main challenges of aquifer-recharge schemes are the costs of construction and monitoring, operation and maintenance, ownership and potential transient chemical reactions with the aquifer material and blended water. Managed aquifer recharge should be seen as one of the water-conservation options available and must be considered as part of an integrated water-management strategy.

Editor's comment:

Adams is correct in his observation that the term "artificial" often has a negative association. From most accounts, recharging of aquifers can make a very positive contribution to integrated water-resource management. However, as is the case with all interventions in the natural environment, an eventual situation, with benefit for all, will require that we proceed with caution.