# Evaluation of existing water recycling technologies in Namibia

## 1. Overview

Direct reclamation became a reality in 1968 In Winddhoek, Namibia when severe water shortages were experienced before the extension of the state water supply scheme could be completed. The first reclamation plant started to operate in 1968 with a capacity of 4,800 $m^3$/d. Since then the reclamation process has undergone various changes of improvement (Haarhoff and van der Merwe, 1995). Investigations conducted during 1991 recommended that with minor changes to the plant, the capacity could be extended and the final water quality improved (Haarhoff, 1991). During a drought in 1992, where state supplies could not deliver the required quantity, the then existing plant was upgraded and extended to an interim capacity of 14,000 $m^3$/d with the intention of ultimately reclaiming 21,000 $m^3$/d. During another severe drought in 1997 it was however decided to build a new reclamation plant at an adjacent site to the Old Goreangab Reclamation Plant. During the period 1992 to 1998, all the components of the reclamation system were reviewed and re-analyzed and incorporated into the design of a new reclamation plant. In September 2002 the New Goreangab Reclamation Plant (NGRP) was commissioned. The old plant is now treating effluents for irrigation of parks and sports fields.

As it is, wastewater has been considered as a resource and natural treatment within the water cycle, like an aquifer, a reservoir in the city of Windhoek. and The water cycle of Windhoek is shown diagrammatically in the figure below.

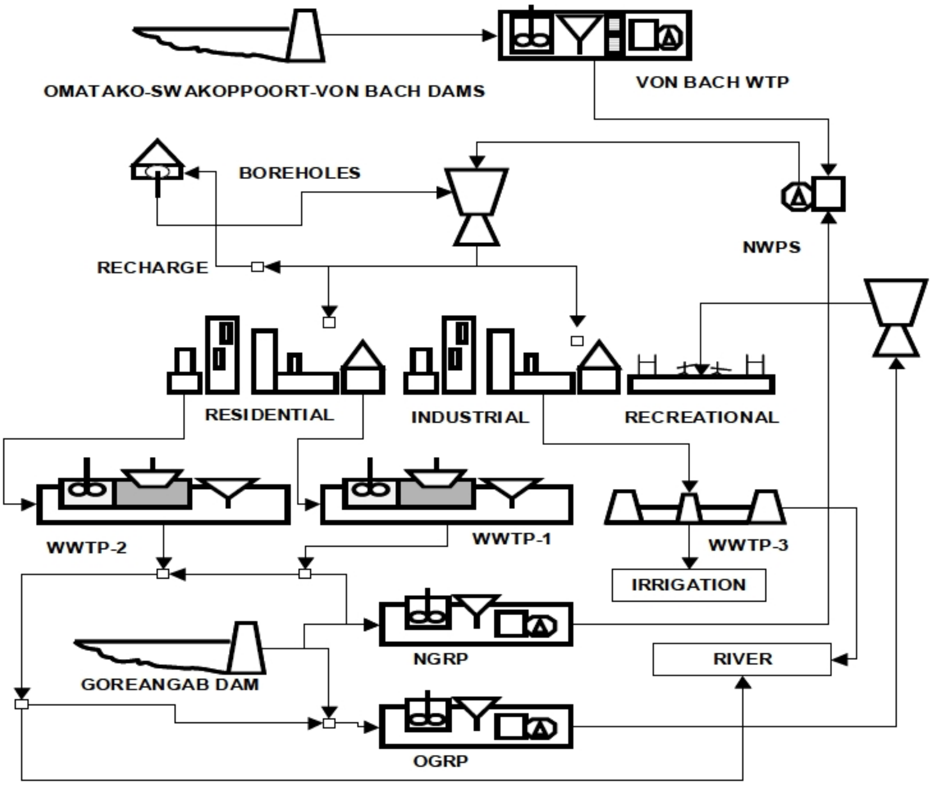


**Figure 1. The Windheok water cycle- Drinking water supply, reclamation and reuse scheme (Treatment of wastewater for re-use in the drinking water system of Windhoek, J. Menge)**

Including water reclamation, there are four main sources of water supply to the central area of Windhoek: surface water obtained from the Von Bach, Swakoppoort and Omatako dams; groundwater abstracted from 50 municipal production boreholes; reclaimed water recovered by suitable treatment from both the New Goreangab Water Reclamation Plant (NGWRP) and the Old Goreangab Water Reclamation Plant (OGWRP). Figure below shows water supply and utilisation for the city's overall water supply scheme, including wastewater reclamation and reuse.

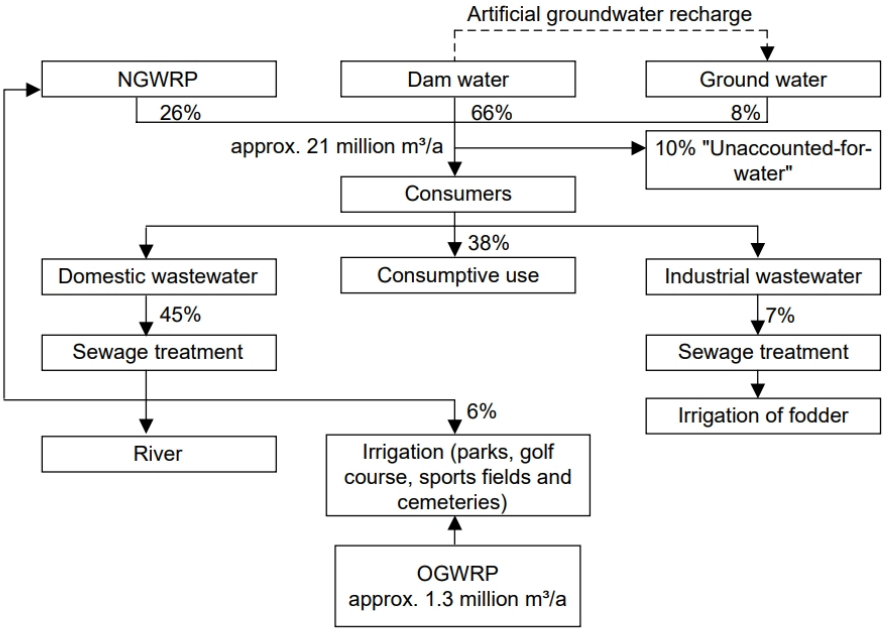


**Figure 2. Water sources and water supply to Windheok**
**(Water Management in Windhek, Nambia, J. Lahnsteiner)**

The practical experience at Windhoek demonstrates that a direct wastewater reclamation system can be a practical, responsible way of augmenting potable water supplies in arid regions, but it requires comprehensive planning, training and on-going commitment for its continued success. (Haarhoff and van der Merwe, 1995)

The Goreangab Wastewater Reclamation (GWR) plant was built in 1968 by the CoW to reclaim potable water directly from domestic sewage effluent as it is mentioned earlier. The Goreangab Company (WINGOC) operates the new GWR plant, completed in 2002. The semi-potable effluent from Gammans Wastewater Treatment Plant treats domestic sewage effluent which is treated to potable drinking quality at new GWC.

## 2. Old Greangab Water reclamation plant

In 1968, a direct water reclamation system from domestic sewage was pioneered in Windhoek, Namibia, to supplement the potable water supply to the city. This system went through a succession of modifications and improvements over the years. The table below shows the different process configurations that were implemented over the years at the Old Goreangab Reclamation Plant (OGRP).

**Table 1. Process configurations and modifications since commissioning**

| C1-1969 – OGRP | C2-1977 – OGRP | C3-1980 – OGRP | C4-1986 – OGRP | C5-1994 – OGRP | C6-1996 – OGRP | C7-2002 – NGRP |
|---|---|---|---|---|---|---|
| Biofilters | Biofilters | Activated sludge-NR | Activated sludge-NR | Activated sludge-NR | Activated sludge-NR | Activated sludge-NR |
| Maturation ponds: 14d | Maturation ponds: 12d | Maturation ponds: 10d | Maturation ponds: 10d | Maturation ponds: 6d | Maturation ponds: 6d | Maturation ponds: 3d |
| *>Carbon dioxide* | *>Lime* | *>Chlorine* | *>Alum + Lime* | *>Ferric* | *>Ferric* | *>PAC* |
| *>Alum* | Settling | *>Alum + Lime* | Dissolved air flotation | Dissolved air flotation | Dissolved air flotation | Pre Ozonation |
| Algae Flotation | Ammonia stripping | Settling | >Chlorine | | | *>Ferric* |
| Foam Fractionation | *>Carbon dioxide* | *>Breakpoint chlorination* | *>Alum + Lime* | | | Dissolved air flotation |
| *>Alum + Lime* | *>Chlorine* | Settling | Settling | | | *>MnO4 + NaOH* |
| *>Breakpoint chlorination* | Settling | | | | | |
| Settling | *>Carbon dioxide* | | | | | |
| Rapid sand filtration | Rapid sand filtration | Rapid sand filtration | Rapid sand filtration | Rapid sand filtration | RSF(ftw) – RSF(ftw)+GAC | Rapid sand filtration (ftw) |
| | *>Breakpoint chlorination* | *>Chlorine* | *>Breakpoint chlorination* | | | *>Ozonation, H2O2* |
| Activated carbon | Activated carbon | Activated carbon | Activated carbon | Activated carbon | Activated carbon | BAC+GAC |
| *>Chlorine* | *>Chlorine* | *>Chlorine* | *>Chlorine* | *>Break point chlorination* | *>Break point chlorination* | Ultra filtration |
| | | | | *>Stabilisation: Lime* | *>Stabilisation: NaOH* | *>Chlorine* |
| | | | | *>Chlorine* | *>Chlorine* | *>Stabilisation: NaOH* |
| Blending | Blending | Blending | Blending | Blending | Blending | Blending |

(Source: Treatment of Wastewater for re-use in the Drinking water system of Windheok)

The old Greangab Reclamation plant is now being used to purify effluent for irrigation. The carbon columns were decommissioned, but the rest of the process remains the same. On average some 3,600 $m^3$/day are currently treated. The demand varies depending whether it is summer or winter or if it rains or not

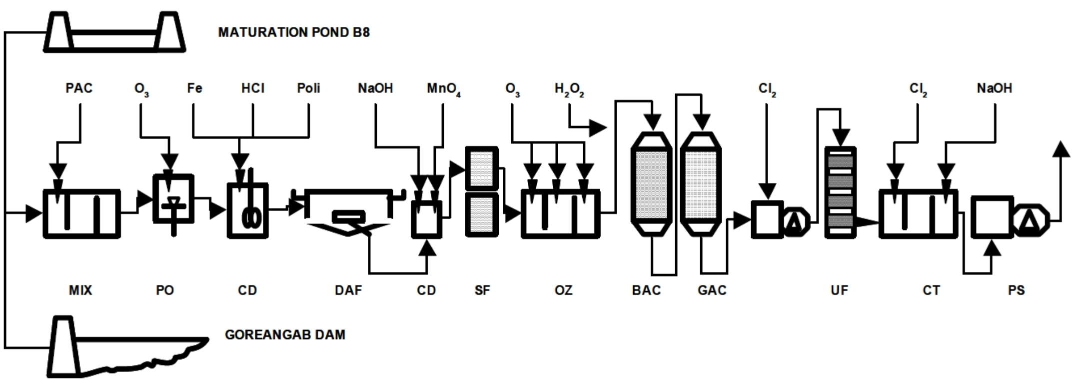


**Figure 3. Process diagram of old Greagab water reclamation plant**
**(Water Management in Windhek, Nambia, J. Lahnsteiner)**

### 3. New Greangab Water reclamation Plant (NGWR)

Regular droughts in Namibia and a continuous shortage of potable water to Windhoek have necessitated the municipality to investigate alternative sources of raw water supply. The most viable option proved to be reuse of municipal wastewater from the largest sewage treat- ment plant in Windhoek, the Gammams Water Care Works, with augmentation from a sur- face water source on the outskirts of the city, the Goreangab Dam. The Old Goreangab Water Reclamation Plant was built over 30 years ago to reclaim municipal effluent for potable water purposes. This plant was upgraded and extended several times during the last 30 years but reached the end of its viable life span in the late 1990s and was also technologically no longer up to date. It was therefore decided to build a new, larger reclamation plant, the NGWRP, using the "multiple barrier" approach. This plant was put into operation in mid-2002 and will now be further elucidated on.

The NGWRP produces 21,000 $m^3$/d of drinking water, safe for human consumption, at all times. To achieve the latter, a "multiple barrier" approach was taken during final selection of the process technology. This means that the treatment processes employed ensure that at least two (in many cases three or more) unit processes are provided for removing each crucial contaminant that could be harmful to the human body or aesthetically objectionable. For example, complete and/or partial barriers for one of the most resistant pathogens, Cryptosporidium, include ozonation, enhanced coagulation, dissolved air flotation (DAF), dual media filtration, ultrafiltration and chlorination. Similarly, five barriers have been included for organic substances, viz. enhanced coagulation, ozonation, biologically active carbon (BAC), granular active carbon (GAC) adsorption and ultrafiltration. This ensures both micropollutant removal and degradation and results in a substantial reduction of the THM formation potential

The following unit processes have been included in the final plant design Powdered activated carbon (PAC) dosing, pre-oxidation and pre-ozonation, flash mixing, enhanced coagulation and flocculation, dissolved air flotation, dual media rapid gravity sand filtration, ozonation, BAC filtration, GAC filtration, ultra-filtration (UF), disinfection and stabilization.

Guarantee values that the final water produced by the plant must adhere to were based on WHO Guidelines (1993), Rand Water (South Africa) Potable Water Quality Criteria (1996) and the Namibian Guidelines for Group A water (NamWater, 1998). Water samples are taken every 4 h at various points throughout the plant and analysed in the plant laboratory for basic quality control purposes. Refrigerated composite samples are taken twice per week and used for extensive analyses of all major water quality parameters as defined for guarantee values.

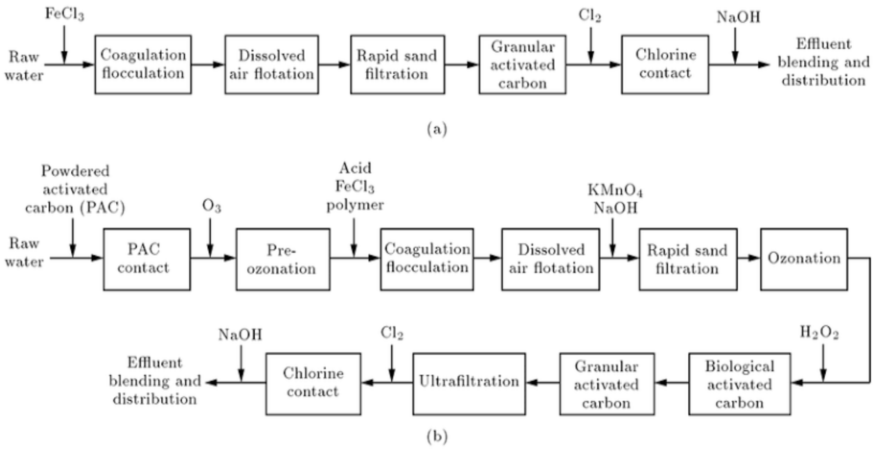

**Table 2. Description of process in New Greangab Water reclamation plant**

| Process | Functions and Description |
|---|---|
| ***Raw water sources:*** | ➢ Goreangab Dam, Maturation Pond effluent from Gammams<br>➢ Wastewater Treatment Plant (GWTP).<br>➢ Both sources can be mixed at any ratio or only one source used at a time.<br>➢ Currently, Effluent from Gammams is only used because the Dam water quality is so bad |
| ***Powdered activated carbon (PAC)*** | ➢ Can be added as back up capacity for adsorption |
| ***Pre-ozone*** | ➢ The raw water mix is treated with the off gas and access ozone |
| ***Chemical dosing and coagulation*** | ➢ Ferric chloride is added as primary coagulant in dosages to achieve enhanced coagulation for maximum organic removal in the first solids separation step<br>➢ Hydrochloric acid can be added if required for pH control.<br>➢ If needed, a polymer can also be added |
| ***Dissolved air flotation (DAF):*** | ➢ Used for solids separation. |
| ***Chemical dosing*** | ➢ Caustic (NaOH) and permanganate (MnO4) are added to raise the pH and accelerate the oxidation precipitation of iron and manganese on the sand filter |
| ***Rapid sand filtration:*** | ➢ Dual media filters with anthracite and graded sand.<br>➢ The filters are equipped with slow start and filter-to-waste facility for maximum cyst/oocyst removal |
| ***Ozonation and ozone contact*** | ➢ Oxygen is produced on-site with a Pressure Swing Adsorption (PSA) plant.<br>➢ Ozone is dosed at three dosage points.<br>➢ Dosage is regulated for maximum Dissolved organic carbon (DOC) removal (1-1.5 mg O3/1mg DOC).<br>➢ A Ct value of 15 at 20 minutes needs to be maintained. |
| ***Chemical dosing:*** | ➢ Peroxide ($H_2O_2$) is dosed to remove any ozone residuals to protect the biological activity in the next step. |
| ***Bacteriological activated carbon filters (BAC)*** | ➢ During ozonation organics with high molecular weight and especially the refractory organic matters are oxidized to produce molecules that are readily biodegradable.<br>➢ These are removed by the biological activated carbon. |
| ***Granular activated carbon filters (GAC):*** | ➢ Consist of primary and secondary filters with a contact time of EBCT = 30 minutes at maximum flow to remove organic molecules from the water |
| ***Ultra filtration (UF):*** | ➢ Chlorinated water is filtered through Ultra Filtration membrane modules to remove bacteria, protozoa and virus.<br>➢ The decision to introduce UF into the process train was based on the fact that protozoa were detected in the final water of the OGRP |

| | |
|---|---|
| ***Chlorination and chlorine contact:*** | ➢ Breakpoint chlorination, free residual of 1 mg/l and<br>➢ contact time of 1 hour |
| ***Stabilization*** | ➢ Adding of caustic to raise the pH to ascertain positive precipitation potential of 4 mg/l |
| ***High lift pumps:*** | ➢ Pumping the final water to New Western Pump Station. |
| ***Blending*** | ➢ New Western Pump Station (NWPS) where the water is blended with surface water from the Von Bach scheme at a ratio 1:3 and introduced into the distribution system |

## 4. Grey water reuse

The Namibian Institute of Mines and Technology (NIMT) now has a waste water treatment plant. It was recently inaugurated on one of the campuses of this training school based in Arandis, in the Erongo region in Northwestern Namibia.

Two containerized units were installed in Arandis, two others in Keetmanshoop and one in Tsumeb. Each unit can produce 20,000 litres of purified waste water per day. The waste water treatment plant therefore has a total capacity of 40,000 $m^3$ per day. This water is then reused for grey water, toilet flushing, car washing and gardening. These reuse services will be provided at NIMT's three campuses.