Managed Aquifer Recharge as a resilient solution to manage groundwater resources: A review of French cases

Pettenati, M.[1a], Picot-Colbeaux, G. [1a], Guillemoto, Q. [1a], Devau, N. [1a], Mathurin, F. [1a], Togola, A. [1a], Maréchal, J.C. [1b]

1 BRGM, Water, Environment, Process Development and Analysis Division, a) 45060 Orléans, Cedex 2-France, b) 34000 Montpellier – France. m.pettenati@brgm.fr; G.Picot@brgm.fr; q.guillemonto@brgm.fr; n.devau@brgm.fr; f.mathurin@brgm.fr; a.togola@brgm.fr; jc.marechal@brgm.fr.

The management of groundwater resources in France mostly focused on water conservation and enhancement of natural recharge of aquifers[1]. In a global context of climate change, these actions are however not sufficient to face water scarcity in some localities. Managed Aquifer Recharge (MAR) can be an sustainable way to maintain and improve groundwater quality and quantity [2]. The French regulation allows MAR on a case-by-case basis by prefectural authorization to prevent saline intrusion, to meet the need of seasonal water demand or to avoid any treated water discharge directly into sensitive surface water bodies. In France, the main sources of water for intentional recharge are surface water (rivers) via infiltration ponds combined with River Bank Filtration (RBF) with drinking water facilities (Table 1, Fig.1). Such systems have been implemented since the 1950s with particular active development in the 1960s, 1980s and 2000s[3].

Location	Starting date of operation	Recharge water volume ($Mm^3\ y^{-1}$)	Recharge system
Croissy sur Seine	1965	30.0 a	Infiltration ponds
Appoigny	1968	0.4 b	Infiltration ponds
Flins-Aubergenville	1980	8.0 a	Infiltration ponds/Bank filtration
Durance river	1980	5.0 a	Infiltration ponds
Vessy	1980	10.0 a	Infiltration ponds
Houlle Moulle	1983	4.4 c	Infiltration ponds
Verneuil sur Seine-Vernouillet	2009	0.7 b	Infiltration ponds/Bank filtration
Hyères-les-Palmiers (France, Var)	2015	0.65 b	Infiltration ponds

Table 1. Most principal manage aquifer recharge sites from surface water in France. a maximum capacity, b estimated annual value, c annual mean during activity period (still operating French major sites from Wuilleumier and Seguin, 2008; SIGESSN).

Figure 1. Most principal manage aquifer recharge in France. https://ggis.un-igrac.org/view/marportal

Figure 2 : Agon-Coutainville WWTP situation

In Normandy, the coastal site of Agon-Coutainville (Fig.2), uses secondary effluent (activated sludge) from the wastewater treatment plant going through a reed bed and a sand dune aquifer[6]. The Soil Aquifer Treatment (SAT) system was chosen from the conventional French direct discharge system into the sea in order to protect the sensitive shellfish production area and acts as a barrier against saline intrusion.

This environmental recharge system has a good efficiency with microbiological reduction rate (3 log removal E.Coli (<100/100ml)). Recent research projects[7,8] have contributed to improve the understanding of the SAT system by developing an ICT management tool and investigating the fate and transport of contaminants of emerging concern in the MAR/SAT environment.

Since 2015, the active management of the main potable water resource of the city of Hyères-les-Palmiers (Fig. 3) has been developed to prevent saline water intrusion of the Bas-Gapeau hydrosystem. Based on a real-time abstraction control and a continuous monitoring (water level, conductivity) on specifically localized piezometers, the hydraulic gradients method shall optimize abstraction without risking saline intrusion. MAR is operated in winter, by infiltration ponds, abstracting coastal Roubaud river water to form a freshwater piezometric dome exploited in summer[4]. The smart-control project[5] has developed solutions to manage online data acquisition with numerical groundwater modelling in order to optimize the management of MAR system (Fig. 4).

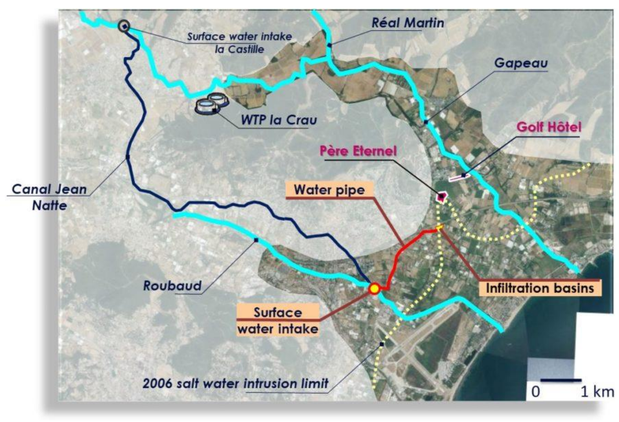

Figure 3. Location of the Aquarenova system and infiltration basin.

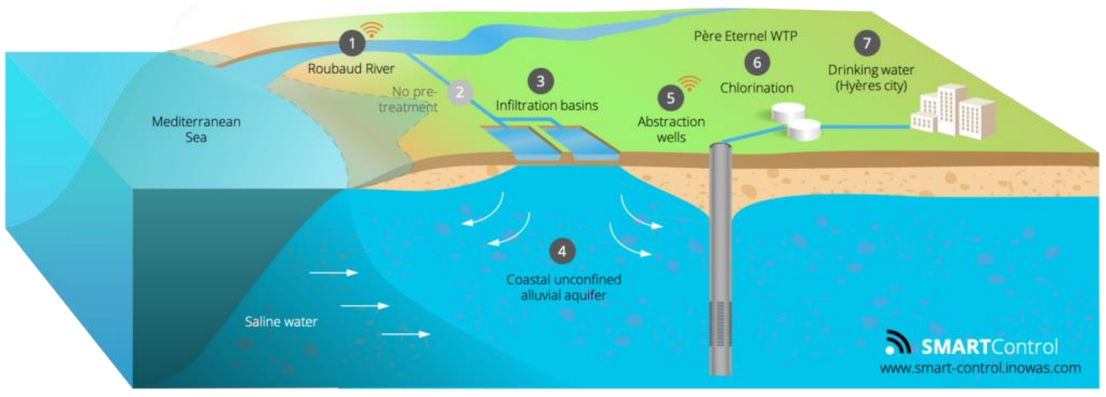

Figure 4. MAR components of the Aquarenova system.

1-Capture zone: Roubaud River Water, 2- Pre-treatment: none, system shut down in case of exceedances of specific parameters, 3 - Recharge: two infiltration basins
4 - Subsurface: coastal alluvial aquifer, 5- Recovery: drinking water wells 400 m upstream of the infiltration basins, 6 - Post-treatment: chlorination at Père Eternel water plant, 7- End use: drinking water.

References: [1] Dillon et al. Hydrogeol J 27, 1–30 (2019) ; [2] Dillon, et al. (2020) Water. 12(7):1846 ; [3] Casanova et al. (2016) Ch. 16, 413-434 in A.J. Jakeman et al. (eds.), Integrated Groundwater Management ; [4] Duzan et al. (2016) AquaRenova Project ; [5] smart-control.inowas.com ; [6] Picot-Colbeaux et al. (2021) in UNESCO book Zheng et al. Eds ; [7]aquanes-h2020.eu ; [8]sintef.no/projectweb/eviban/