COMMISSION INTERNATIONALE
DES GRANDS BARRAGES

VINGTIÈME CONGRÈS
DES GRANDS BARRAGES
Beijing, 2000

FUNCTION OF RESERVOIRS IN THE ARTIFICIAL RECHARGING OF UNDERGROUND AQUIFERS: THE ALGAR AND BELCAIRE RESERVOIRS AS CASES WITH SPECIFIC RECHARGING FUNCTION(*).

Enrique CIFRES
Head of Construction Department of the Júcar river Water Authority
Professor on Dam Engineering. Polytechnic University of Valencia.

INTRODUCTION

A priori the imperviousness of the reservoir area is considered one of its most valuable qualities and indeed this is so in the majority of cases. On the other hand, in some cases, the beneficial effect on the aquifers receiving the filtrations of some reservoirs the imperviousness of which has not been completely satisfactory is well known,

In particular, the majority of the reservoirs with base area established on pervious calcareous formations (triassic, jurassic..) are concentrated in the east of the peninsular, among which there are numerous cases of considerable losses by filtration. Where the coastal aquifers suffer overexploitation, this gives rise to problems of quantity, because of a negative hydric balance, therefore unsustainable, as well as of quality, as they suffer salinization by marine intrusion, by addition of nitrogenated fertilizers, etc.

The losses of some existing reservoirs to the underlying mesozoic aquifers, which were not counted on in their original conception, have been shown to be highly beneficial or even essential. To take a clear example, it would not be acceptable to the users of the waters of the River Mijares, which benefit from the regulation of the Sichar and María Cristina reservoirs, both with significant

* *Fonction des reservoirs dans la recharge artificièle des aquifers sousterraines: Les reservoirs de Algar et Belcaire comme cases avec fonction especifique de recharge.*

filtrations, to rectify this situation, which in other times would have been qualified as desirable. And this is owing to the fact that the aforementioned users are also users of the Plana de Castellón aquifer, the difficulties of which are partly alleviated by the aforementioned filtrations. For this reason, it is not only advisable to maintain this situation, but also in some cases to promote it with some advantages as will be shown.

In the hydrological plans of some basins, in particular that of the Júcar, interventions are contemplated the object of which is to artificially recharge aquifers. Outstanding among these is the construction of reservoirs to allow the viability of the intended recharging, taking advantage of the two essential qualities of these which may or may not coexist:

1 - The inundation of pervious areas of recharging

2. - The regulation of intermittent high flows to transform them into moderate and relatively constant flows, appropriate for recharging

A third function, although of a more accessory nature would be the decanting of the waters to be used for recharging, avoiding the infiltration of sediments.

To illustrate the advantages of the dams in this new function, the problems of the coastal aquifers of the plains de Castellón and Sagunto will be examined, which form a continuous and relatively homogenous strip.

THE “PLANA DE CASTELLÓN”

The paradigmatic case is that of the Plana de Castellón, where the traditional irrigation is based on a quaternary aquifer fed by the mesozoic aquifers which drain water resources infiltrated in some eminently calcareous basins. (See figure 1)

The traditional age-old irrigation of the River Mijares, has been able to be developed because of the high guarantee of flow from the upper Mijares basin, where a large mountain aquifer (Javalambre) drains naturally regulated flow. As well as these guaranteed surface resources, the also superficial runoff of a more variable character, owing to the temporal irregularity of the precipitations must be added, and the underground resources which infiltrated in the catchment basins, drain into the sea through the the mesozoic formations and feed laterally the quaternary aquifer upon which the irrigated zone is based.

This circumstance has led the development of the irrigation to take the following logical process:

1. Traditional irrigation based on the base flow guaranteed by the river.
2. Extension of the irrigation by means of the construction of regulation reservoirs. (María Cristina Dam 1920, Sichar Dam 1960 y Arenós Dam 1979)
3. Underground exploitation of the quaternary aquifer, together with the regulated surface water. (phase overlapped with the later era of the 2)

4. Overexploitation of the underground water due to the ease of access to non-renewable underground resources.

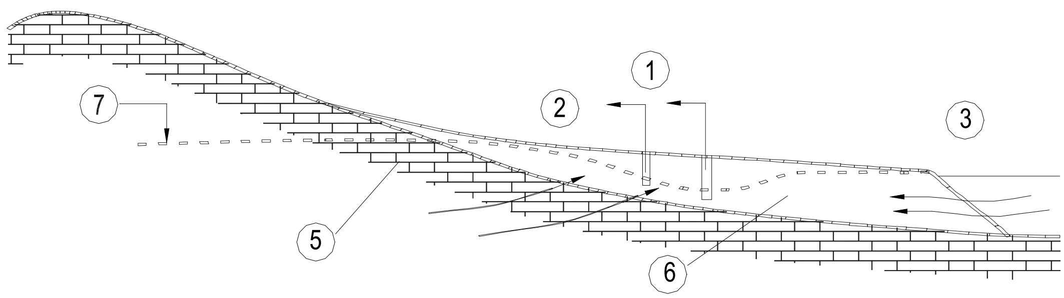


Fig. 1 : Cross section at the coast.. / *Coupe à la zone de côte*

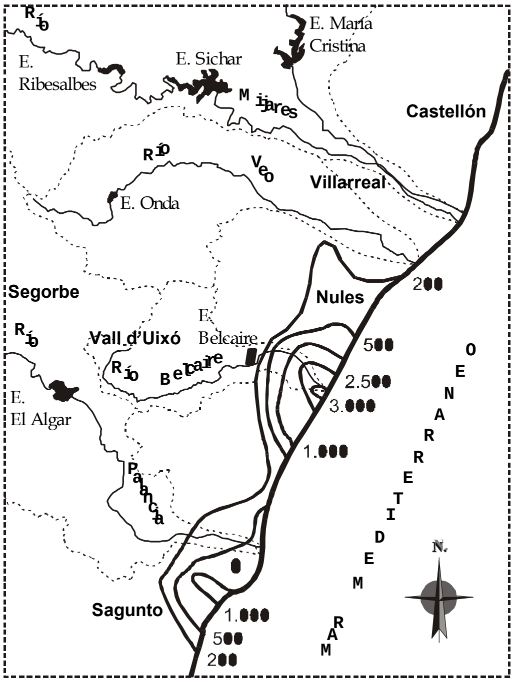
1	Pumpings	*Pompage / Puits*
2	Irrigation area	*Zone d'irrigation*
3	Mediterranean sea	*Mer Méditerranée*
4	Salt water intrusion	*Pénétration du saumure*
5	Mesozoic	*Mésozoïque*
6	Plioquaternary	*Plioquaternaire*
7	Phreatic surface	*Nappe phréatique*

This last phase is the consequence of the excessive overvaluation of the underground resources, confusing those available in the short term with those that are renewable. Note that it is habitual to qualify a well by its gauging, which measures the ease of access of the water to the borehole and not the resources really available.

On the other hand, there has been a tendency to not consider the fragility of the aquifer systems both in their balance, difficult to ascertain, as well as in their quality, because of their inertia in the diffusion of salts, be they contributed via the marine interface in cases of intrusion or contributed by the fertilization system itself by means of percolation of nitrates.

In figures 2 and 3 the general situation of the quaternary aquifer is represented, where a generalized saline intrusion is observed that exceeds 3 gr/l of chlorides proceeding from sea water, as piezometric levels below the level of this in large areas. .

In the specific case of the Plana de Castellón, these effects have been protracted in time due to the contribution of waters recharged by the Sichar and María Cristina reservoirs. Both have base areas which inundate areas of jurassic and cretaceous formations which recharge the mesozoic aquifers, which in turn feed the most exploited quaternary aquifer. Also, although to a lesser extent, the mesozoic aquifer is directly exploited.



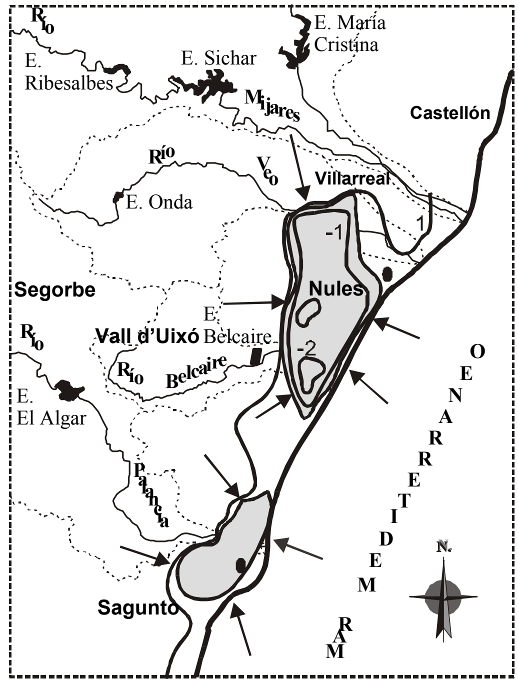
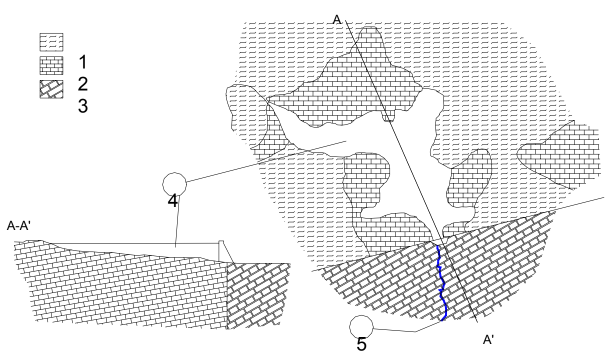


Fig. 2 : Map of isochlorides / *Carte des isochrones*

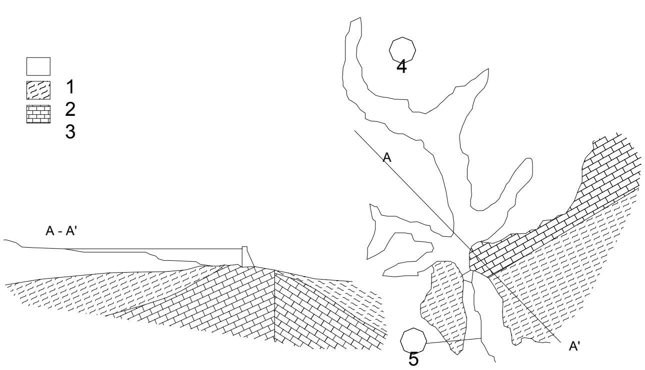
Fig. 3 : Piezometric map / *Carte piézomètrique*

In figures 4 and 5 the hydrogeological surroundings of the Sichar and María Cristina reservoirs are represented.



1) Tertiary / *Tertiaire*. 2) Cretacic / *Crétacé. 3) Jurassic / Jurassique 4)* Reservoir / *Réservoir 5) River Mijares / Fleuve Mijares*

Fig. 4 : Sichar Reservoir/ *Reservoir de Sichar*



1) Plioquaternary *// Plioquaternaire. 2)* Cretacic / *Crétacé. 3)* Jurassic / *Jurassique. 4)* Reservoir / *Réservoir 5) De la Viuda Creek / Oued*

Fig.5 : María Cristina Reservoir / *Reservoir de Maria Cristina*

The first of these is situated upon the River Mijares itself, the second upon its last tributary on the left: La Rambla de La Viuda. Also the River Mijares itself downstream of the reservoir, where it flows “hanging” with respect to the aquifer, contributes to the recharging of resources.

The following river beds further south are:

- The River Ana, regulated by the Onda reservoir at the head which does not contribute resources to the lower zone.
- The River Belcaire, not regulated, with intermittent flow which goes out to sea, by a passage which hardly recharges the aquifer at all. It loses between 6 and 8 Hm3/year to the sea.
- The La Fuente de La Llosa and Quart springs, which drain mesozoic aquifers of moderate extension directly to the surface, but which historically have guaranteed natural regulated flow to their surroundings. The profusion of wells in the surroundings has lowered the general level so that these springs, historically continuous have become intermittent losing their guaranteed character and causing new underground extractions.

The River Palancia, which in its lower basin, once it flows through the carbonated formations of the triassic outcrops to end up upon the quaternary plain, loses its flow. It is regulated at the headwaters by the small Regajo reservoir (6 Hm^3). The surface runoff of the mid and lower basins, when it occurs, is taken advantage of directly or flows out to sea. The case of the River Palancia will be dealt with in more detail.

As a general diagnosis, it may be said that the situations of the quaternary aquifers included between Castellón y Sagunto are found to be deteriorated by an imbalance in the use of their waters in preference to the renewable resources, giving rise to problems of quantity as well as quality. In practically all the towns situated in the Plana, where drinking water supplies proceed from the aquifer, they show levels of nitrates above 50 mg/l rendering them invalid for human consumption.

The inertia of this situation of exploitation of the aquifers, with extremely high private investments in the infrastructure of extraction and the organization of the surrounding irrigation (note that the majority of the irrigation has no surface resources or has insufficient), complicates the solution of the problem.

PROPOSAL OF RECHARGING RESERVOIRS

The filtration of the surface resources lost to sea because of the lack of regulation is one of the strategies adopted to mitigate the problem, together with others such as those tending to reduce the demand (modernization of irrigation, implantation of localized irrigation,..) or the reutilization of treated sewage, which currently reaches a relatively high level of exploitation.

As has been shown previously, there are two qualities of the reservoirs which makes them ideal for this purpose:

The inundation of areas made up of pervious formations which feed the aquifers and the temporal regulation of the intermittent flow.

In the case of the Algar dam, currently under construction on the River Palancia, both circumstances occur simultaneously. In the case of the Belcaire reservoir, recently projected on the river of the same name, the second occurs, due to the intensive land use around the area of Vall d'Uixó where it is situated.

In order to propose this objective it is necessary to justify beforehand, the effectiveness of this type of reservoir by means of a simple analysis.

A brief history of the background of the Algar dam will make the reason for this type of analysis more comprehensible.

The traditional irrigation of the River Palancia has been developed through the centuries from the guarantee of the surface flow proceeding from the drainage of the upper basin, where it is naturally regulated by a system similar to that described for the River Mijares, a mountain aquifer. This regulation was increased with the Regajo reservoir which takes advantage of an impervious base area to transform relatively continuous flow into a supply closer to the temporal variation in the demand.

The lowest stretch of the River Palancia, losing its flow by "hanging" temporally, but habitually, with respect to the aquifer, has historically caused the main irrigation channel (Acequia Mayor de Sagunto) to move up its intake, seeking points further upstream in order to reduce the loss of flow by river-aquifer infiltration.

Nevertheless, the lack of sufficient resources has led to a social historic demand (there are records from the 18th and 19th centuries) for a dam to be situated in the area of the confluence of the Azuébar stream, last tributary of the left bank, near to the area of the intake of the aforementioned channel. Precisely, at the end of the 19th century, the project for the Azuébar dam was drafted, situated upon the stream close to the confluence, with the mission of regulating the flow of this and the Palancia, diverted to its reservoir by a channel for this purpose. The project, the financing of which was established to be charged to its users, involved the creation of the corresponding works council and the initiation of the construction at the beginning of the present century. The incipient studies carried out at the time of the perviousness of the reservoir area gave rise to the fear of the inefficacy of the reservoir and gradually the users withdrew their financial support.

Various attempts to restudy the reservoir in the zone always gave rise to unfavourable reports on the watertightness of the site area and to giving up the attempt

The later development of the boring and extraction systems allowed the development of irrigation via the use of surface water (that available at the head regulated by the Regajo reservoir) together with underground supplies, reaching the point of exceeding the renewable resources of these and the beginning of an unsustainable process of exploitation of the aquifer.

It was not until 1980 that the studies of the combined use of surface and underground water showed the possible utility of a pervious reservoir in the area of the repeatedly studied Azuébar dam (today named the Algar dam). This turn-around of approach, since the exploitation of the aquifer had inverted the objectives, has led to the current project and construction of the Algar dam.

Through a simple mathematical model of the River Palancia basin, the beneficial effect which a pervious reservoir has on the regulation of the total water resources will be illustrated.

Figure 6 represents in a simplified form the simulation model of the basin carried out for the analysis of the efficacy of a pervious reservoir in the overall exploitation of the water resources of the basin.

The resources filtered into the mountain aquifers of the upper basin partially drain into the fluvial system and laterally recharge the aquifers of the mid-basin, also recharged naturally by direct filtration of rainwater.

In turn, these aquifers laterally feed into the quaternary aquifer which is exploited for irrigation. This aquifer may drain partially into the sea or receive salt water from this depending on the gradient established in the interface zone.

A reservoir which allows the regulation of the surface resources would make it possible to increase the surface resources exploited, reducing the level of extraction and thereby avoiding the negative balance of the aquifer.

But it is possible to question from the classic regulation approach:

What capacity of reservoir would be necessary? Is it possible to establish this by the existence of a site and sufficient reservoir area? Are there impervious areas which allow this?

On the other hand,

If the reservoir is pervious, is it possible to redress the balance of the aquifer satisfying the demand for a sustainable approach to the utilization of resources? If so, with what capacity? Does a reservoir area exist for this?

In order to answer these questions, the result may be seen of the analysis by means of a simple mathematical model where the aquifers are simulated as lineal reservoirs. The simulation has been carried out using the Montecarlo method with series of synthetic monthly flows.

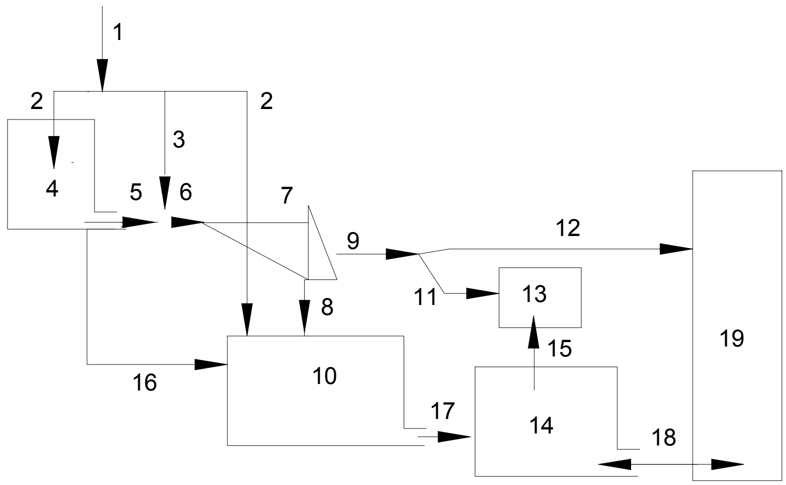


Fig.: 6 : Scheme of simulation model
1) Rain 2) Natural recharge by filtration 3) Direct runoff 4) Mountain aquifer 5) Spring drainage, base flow 6) Available surface resources 7) Reservoir 8) Recharge induced by the reservoir 9) Withdrawal from reservoir 10) Intermediate aquifer 11) Demand supplied by the river/reservoir 12) Discharge to sea 13) Irrigation zone 14) Exploited aquifer 15) Pumpings 16 y 17) Lateral recharge 18) Interchange aquifer - sea at the interface 19) Sea

1) Pluie 2) Relèvement de la nappe phréatique par infiltration 3) Ecoulement 4) Aquifère de montagne 5) Ecoulement résourgences, débit base 6) Ressources superficiels disponibles 7) Réservoir 8) Relèvement amenée par le réservoir 9) Déstockage 10) Aquifère intermédiaire 11) Demande satisfait depuis le fleuve/réservoir 12) Renvesé à la mer 13) Zone d'irrigation 14) Aquifère exploité 15) Pompages 16 y 17) Relèvement latéral 18) Échange aquifère - mer à l'interface 19) Mer

RESULTS OF THE ANALYSIS

In order to solve the problem as conceived historically, by means of surface regulation a reservoir of over 50 Hm3 would have been necessary to satisfy 98% of the current demand and 100 Hm3 for 100% of the demand. There is no impervious reservoir area. If it had to be impervious, no sites exist which offer that capacity of reservoir in the lower Palancia basin, without inundating important towns.

If the reservoir area is pervious (very difficult to quantify) the stored water is retained temporally, so that part of it will become regulated flow and part will filter in recharging the intermediate mesozoic aquifer. In this case, what capacity of reservoir would solve the problem of supply without using the aquifer?.

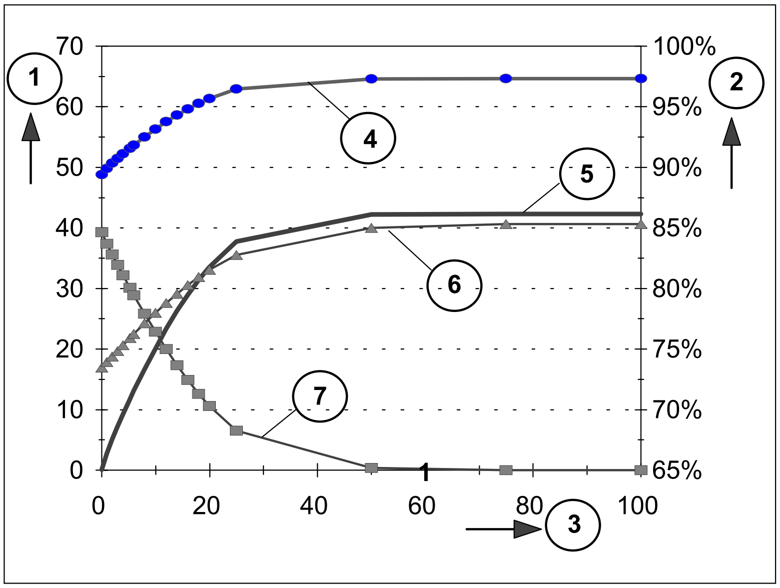


Figure 7: Regulation produced by a reservoir with losses by filtration, increasing with the level of the reservoir. / *Réglementation produite par le réservoir par pertes pour infiltration, augmentation avec le niveau du réservoir*

1	Annual volume (Hm^3/year)	*Volume annuel (Hm^3/an)*
2	Supplied demand	*Demande satisfait*
3	Useful reservoir capacity (Hm^3)	*Capacité du réservoir (Hm^3)*
4	Surface achieved resources	*Aménagement superficiel*
5	Supplied demand	*Demande satisfait*
6	Outflow to the sea through interface	*Renvesé à la mer par l'interface*
7	Lost waters to the sea	*Embouchure du fleuve au mer*

It may be appreciated that it is not possible to supply more than 86% of the demand, not increasing the regulated volume above a capacity of some 50Hm3. This explains the intuition of the users who withdrew from this strategy. On average 23.7 Hm3/year of surface water would go out to sea through the aquifers owing to the existence of the reservoir. An exclusively surface level solution is therefore not possible.

This led to the progressive exploitation of the aquifer, currently even above the levels of sustainability, since it exceeds the level of natural recharging and the underground system enters into a process of degradation, as now occurs.

Nevertheless, it is still possible, although in the long term, owing to the inertia of the system, to bring it back to a level of balance by means of a reservoir, impervious or otherwise.

In order to analyse this case, let us suppose that the rule of operation of the system is to use the existing surface resources and complement the demand with extractions. What volume of reservoir would be necessary so that the balance of intakes and outlets of the aquifer would give rise to a sustainable situation?

From the results of the simulation in figure 8, it may be observed that in the case of a watertight regulation reservoir, the net null outlet to the sea (limit of sustainability for the simplified purposes of the analysis) is produced with a capacity of some 9 Hm3, and the reduction of extractions required for this is of 9.4 Hm3/year with the consequent saving of energy.

However, in the case of a filtering reservoir, the balance is achieved with a capacity of 5.25 Hm3 and a reduction of pumping of 6.3 Hm3/year, rather less than in the previous case.

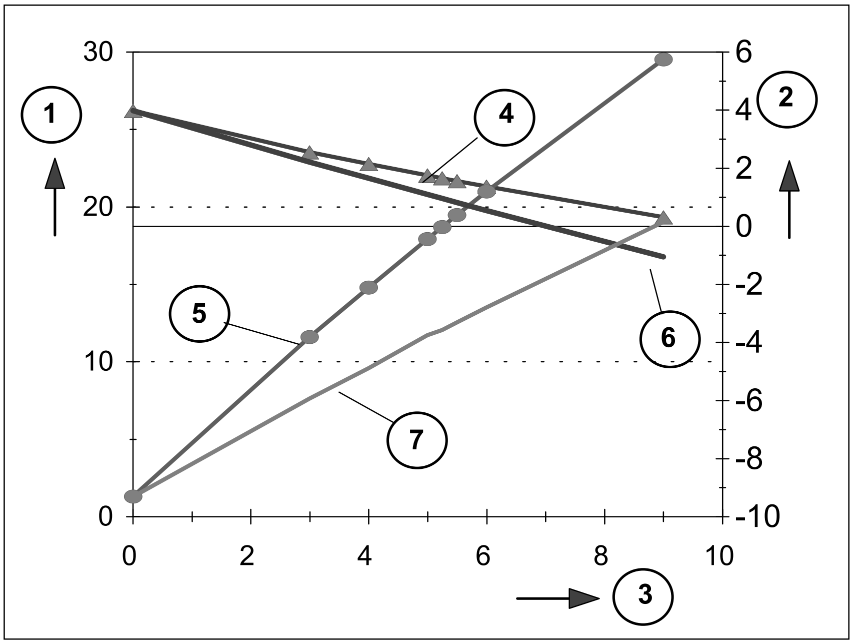


Fig. 8: Comparison filtering vs. watertight reservoir../ *Comparaison entre réservoir perméable et imperméable*

1	Pumpings (Hm^3/year)	*Pompages (Hm3/an)*
2	Lost waters to the sea (Hm^3/year)	*Renvesé à la mer (Hm3/an)*
3	Useful reservoir capacity (Hm^3)	*Capacité du réservoir (Hm3)*
4	Necessity of pumping	*Pompages nécessaires*
5	Outflow to the sea through interface	*Renvesé à la mer par l'interface*
6	Necessity of pumping without filtration	*Pompage nécessaire sans filtration*
7	Outflow to the sea through interface without filtration	*Renvesé à la mer par l'interface sans filtration*

The difference is that the first case is not technically possible whereas the second is for two reasons:

- The existing site (practically unique) has its capacity limited by the existence of a village, Sot de Ferrer, at the tail of the reservoir, at 6.3 Hm^3.
- The reservoir is pervious

Nevertheless, these parameters fit perfectly within the second approach, where it is possible to redress the balance with a capacity of 5.25 Hm^3 and only 2.5 Hm^3/year of additional pumping.

The non-existence of the reservoir, which represents the current situation, (see figure 9) means that sustainability is not possible supplying 100% of the demand, which involves a consumption of non-renewable resources of 9.39 Hm^3/year. The balance is clearly exceeded from an extraction of above 17 Hm^3/year.

Figure 10 represents the result of the simulation for the combined use proposed. From over 5.25 Hm^{3}reservoir capacity there begins to be a net outlet to sea, so that a reservoir of 6.3 Hm^3, such as that proposed in Algar, gives hope of a gradual, albeit long-term recovery of the aquifer, recuperating the sustainable usage of the water resources of the basin.

The analysis demonstrates the greater efficacy of a permeable reservoir for the case of combined use proposed, since the objectives are achieved with lesser capacity although, logically, with energy cost for the greater extraction compared with a surface supply.

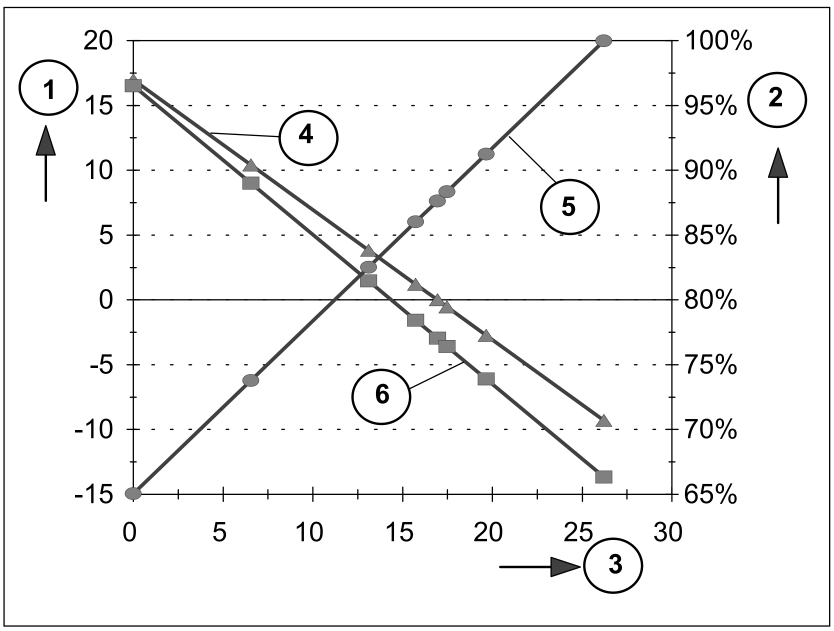


Fig. 9: Without reservoir / *Sans Réservoir*

1	Hm^3/year	*Hm^3/an*
2	Supplied demand	*Demande satisfait*
3	Surface water resources	*Ressources superficiels*
4	Outflow to the sea through interface	*Renvesé à la mer par l'interfac*
5	Supplied demand	*Demande satisfait*
6	Transient outflow to the sea through interface	*Renvesé souterraine transitoire à la mer*

The analysis, in qualitative terms, illustrates the positive effect of a reservoir when according to the conventional approaches it would have been ruled out. Moreover, it demonstrates a positive aspect from the environmental point of view and the rôle of the surface water not yet regulated, as a last hope for the exploitation of fragile underground resources. All this is possible thanks to two effects of the reservoir: its capacity to inundate areas which feed into the aquifer and its regulating component, which allow intermittent runoff of volume that would not have been filtered in due to lack of time, to do so at the pace that the recharging area permits.

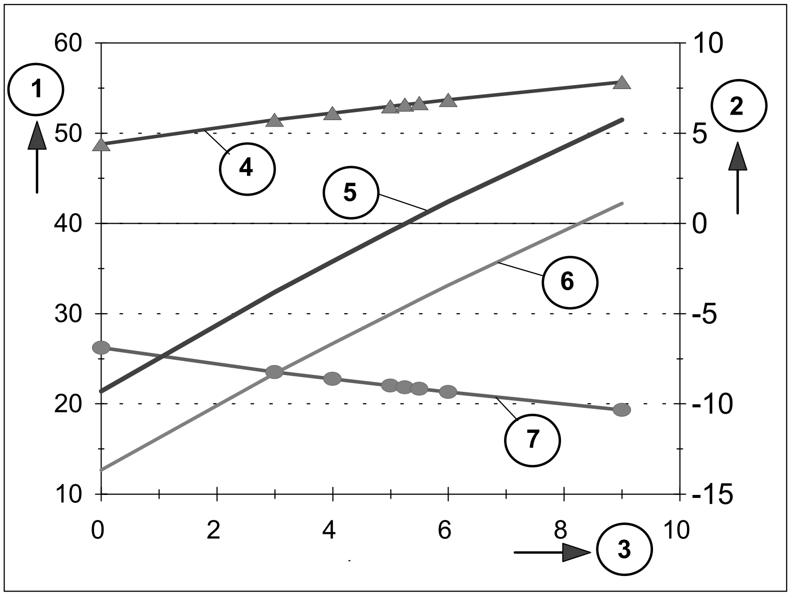


Fig. 10: Combined use of pervious reservoir / *Utilisation conjointe avec réservoir perméable*

1	Annual volume (Hm^3/year)	*Volume annuel (Hm3/an)*
2	Salidas al mar (Hm^3/year)	*Renvesé à la mer*
3	Storage capacity (Hm^3)	*Capacité du réservoir (Hm3)*
4	Surface Achieved Water Resources	*Ressources superficiels profités*
5	Outflow to the sea through interface	*Renvesé à la mer par l'interfac*
6	Transient outflow to the sea through interface	*Renvesé souterraine transitoire à la mer*
7	Necessity of pumping	*Pompages necessaires*

The final precise quantification of the analysis will not be able to be carried out unfortunately until experience allows the real filtrations to be known, and an improved modelling of all the aquifers involved in the model of the general basin can be reliably carried out. Nevertheless, the validity of the conceptual approach with approximated data is to be emphasized.

THE ALGAR RESERVOIR

All the previous model would not be valid without a hydrogeological study which confirms that the reservoir indeed recharges the aquifer in question and by what mechanisms it does so. On many occasions the filtrations return to the river downstream of the reservoir and if this were so with all of these, it would hardly have signified any conventional surface regulation, with the difference that the flow is not dried up by the intakes of the dam.

Figure 11 shows the hydrogeological scheme of predicted recharging by the Algar dam. One of the users who is waiting for it to be put into operation with greatest expectation is the irrigation zone of the Fuente de Quart (see NE corner of the figure) previously mentioned, since this constitutes a drainage of the triassic carbonated aquifer which the reservoir will feed into. This zone is hydrologically outside the Palancia basin, although it belongs to the same Administrative unit.

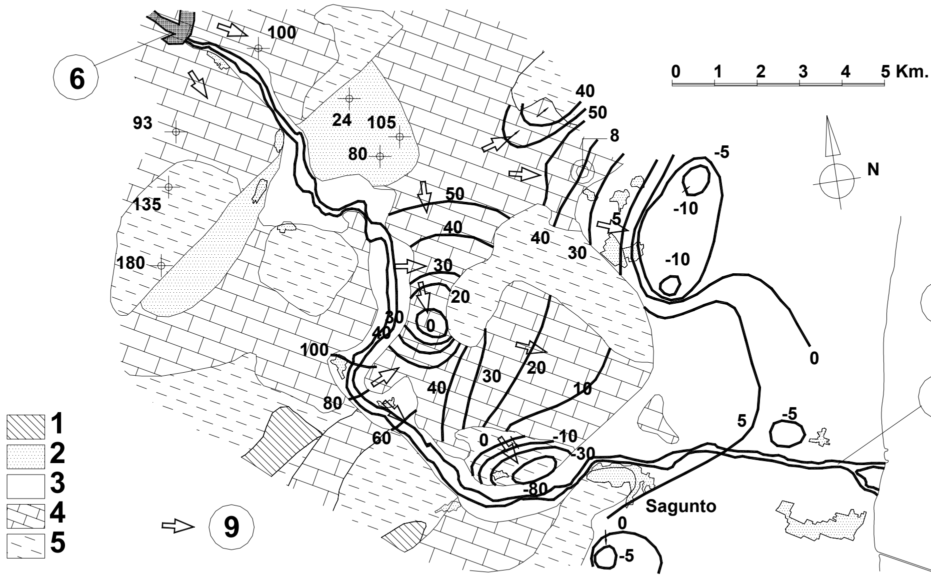


Fig.11: Scheme of the predicted recharging by the Algar reservoir / *Schéma du relèvement prévu avec le réservoir d'Algar*

1	Without aquifer	*Sans Aquifére*
2	Tertiary Slow Aquifer	*Aquifére lente tertiaire*
3	Detritic quaternary	*Détritique quaternaire*
4	Carbonated triassic-jurassic	*Carbonaté Triasique-Jurassique*
5	Silicean triassic	*Silicieux triasique*
6	Algar Reservoir	*Réservoir d'Algar*
7	Mediterrarean sea	*Mer Méditerranée*
8	Palancia River	*Fleuve Palancia*
9	Underground flow direction	*Direction du flux souterraine*

THE BELCAIRE RESERVOIR

In the interfluvial area Palancia - Mijares is the River Belcaire where there is an irrigated zone with practically no exploitation of the surface resources. The irrigated zone depends exclusively on underground water supplies. The development of the irrigation, intensified by the deindustrialization of the zone with the consequent increase in the agricultural sector, has given rise to a locally very acute hydric deficit, to saline intrusion which shows levels of over 3 gr/l of chlorides at 14 km from the sea and an irrigation with salinized waters which hardly seems possible to solve with the resources given.

Among the measures adopted, the whole catalogue of strategies is to be found: modernization of the irrigation by means of the generalized implantation of localized irrigation, complete exploitation of treated sewage, mixture of salt and fresh water to reduce the salt content to transitorily tolerable limits, etc..

Even so the deficit will not drop below 6 Hm3/year. The exploitation of the intermittent surface resources of the River Belcaire and the Cerverola Stream, tributary of the right bank of this, is the last endogenous resource. The recharging of the aquifer of the Plana de Castellón in its southern sector (which involves us) where it presents its worst conditions in all aspects (quantity - quality) is one of the objectives of the Hydrological Plan of the Basin

The recently projected Belcaire reservoir, contemplated in the Plan of the Basin, has as an aim the regulation of the winter surpluses of the San José spring, a natural intermittent source which, with only a few days delay, drains the filtered water of intense precipitations of a highly pervious basin, but rapidly drained by the aquifer. The drainage of this occurs through the touristic and visitable in much of its length, underground river of San José in Vall d'Uixó. This fact means that the majority of the torrential rainfall is partly routed by the aquifer, giving rise to flow with lower peaks and, on drainage in the following days (about a week), with flows of around 8 - 10 m3/sec which is the capacity under load of the karstic channel of drainage.

In spite of the non-existence of sites on the river downstream of this unique point (true source of the river) this circumstance allows a diversion channel to be dimensioned into a regulating reservoir outside the riverbed.

The system of exploitation is illustrated in figure 12. The reservoir will divert the intermittent flow from the river before receiving the occasional dicharges of the Urban Sewage Treatment Plant, which may invalidate the delicate process of recharging. Once diverted, it is regulated by an artificial reservoir of 2 Hm3 and then led to the recharging zone at the constant pace which is advisable.

The dimensioning of the capacity of the channel and the reservoir offer a classic example of regulation and require no further comment.

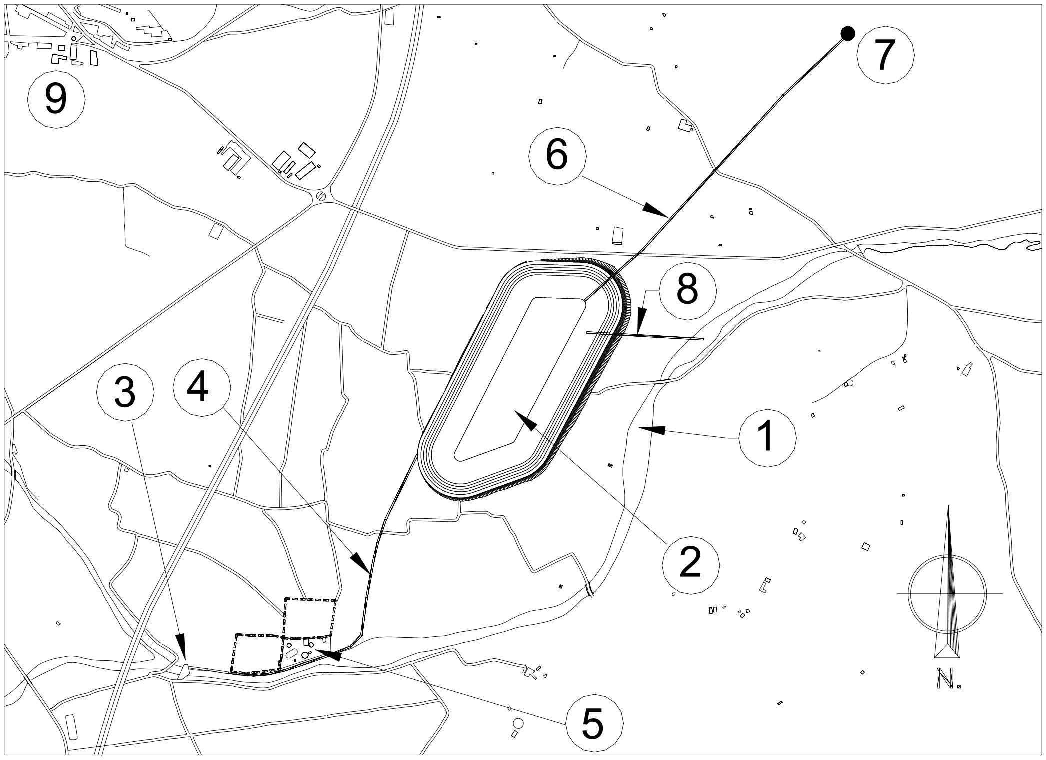


Fig. 12: The Belcaire Reservoir / *Reservoir du Belcaire*

1	River Belcaire	*Fleuve Belcaire*
2	Belcaire Reservoir	*Réservoir du Belcaire*
3	Diversion dam	*Barrage de dérivation*
4	Channel	*Canal*
5	Sewage treatment plant	*Plante de nettoyage*
6	Recharging conduction	*Conduite de relèvement*
7	Recharging wells	*Puits de relévement*
8	Bottom outlet	*Vidange de fond*
9	City	*Ville*

CONCLUSION

The combined usage of surface and underground water offers a new rôle to dams as fundamental pieces of exploitation: recharging aquifers, thanks to some qualities that these offer: a) the inundation of areas feeding aquifers, causing direct recharge, b) their regulating effect, essential to produce the recharge of intermittent volumes of runoff at the pace that the infiltration mechanism allows and c) the decantation of flood water with solids undesirable to the recharge mechanisms.

It has been shown how some cases of reservoirs ruled out from a classical regulation approach, are possible and even the only possibility of effective and sustainable exploitation of the water resources.

SUMMARY

In the first part of this paper the question of the coastal aquifers suffering problems of quantity (balance) and quality (salinization) is examined and the beneficial effect on these of the recharging induced by the reservoirs is described, all of which is illustrated by diverse reservoirs of the Júcar River Basin.

This fact not initially intended, but currently borne out by experience, has served as a fundamental idea for projecting reservoirs with the *a priori* mission of provoking the artificial recharging of aquifers.

In the second part of the paper, it is therefore proposed to include of a new use of reservoirs: the recharging of aquifers as an environmental corrective measure, for a sustainable exploitation of the continental water resources. Among the reservoirs being developed in the basin with this purpose, are the Algar reservoir, (currently under construction), and the Belcaire, recently projected. Through the cases examined, it is shown how the regulation produced by the reservoir allows an improved exploitation of the surface resources, taking advantage of the additional regulating capacity of the aquifers in an environmentally more favourable approach.

RESUME

Dans la communication on expose dans une première partie la problématique des aquifères côtières soumis aux problèmes de quantité (bilan) et qualité (salinité) décrivant aussi l'effet bienfaisant sur eux de la recharge induite par les réservoirs, tout cela illustré par les diverses réservoirs de la bassin du Júcar.

Ce fait non prétendu initialement, mais actuellement ratifie par l'expérience, a servit d'idée maîtresse pour l'emplacement des réservoirs ayant pour mission à priori de provoquer la recharge artificielle des aquifères.

Dans la deuxième partie de la communication on propose alors, l'inclusion d'un nouvel usage des réservoirs: la recharge des aquifères comme mesure de correction de l' environnement, pour une exploitation soutenable des ressources hydrauliques continentales. Parmi les réservoirs promus dans le bassin avec cette finalité, ce situe les réservoirs de l'Algar, actuellement en construction, ainsi que celui de Belcaire, récemment en projet. A travers des cas exposés s'illustre comment la régulation produite par le réservoir permet un meilleur profit des ressources superficielles, en permettant de profiter également de la capacité régulatrice des aquifères dans une conception environnementale plus favorable.