COMMISSION INTERNATIONALE
DES GRANDS BARRAGES
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VINGT TROISIÈME CONGRÈS
DES GRANDS BARRAGES
*Brasilia, Mai 2009*
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# THE SILTING PROBLEM FOR RESEVOIRS OF ITALIAN LARGE DAMS *

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ITALY

* *Le problème de la sédimentation dans les grands barrages italiens*

## 1. WATER STORAGE CAPACITY OF LARGE DAMS IN ITALY

The Italian codes defines large dams as those exceeding 15 m in height and/or with a reservoir capacity exceeding 1 $hm^3$. According to official data updated to march 2007 [18], large dams in Italy are 543, 15 of which out of operation (see Fig. 1).

The total storage capacity is about 13,350 $km^3$. As showed in Fig. 2, the medium age of Italian large dams is about 66 years.

## 2. SILTING ESTIMATE FOR THE RESERVOIRS OF ITALIAN LARGE DAMS

The total amount of silting of Italian reservoirs has been estimated making reference to data relevant to 285 reservoirs, which represent about 52 % of all the Italian large dams, and correspond to a water storage capacity of 7,35 $km^3$, thus amounting to about 55% of the total storage capacity (13,35 $km^3$).

First of all, the reservoirs with an associated decrease of storage volume quantified in less than 5%, are being classified as devoid of silting. This choice reflects the degree of uncertainty which is intrinsic to the measurements performed.

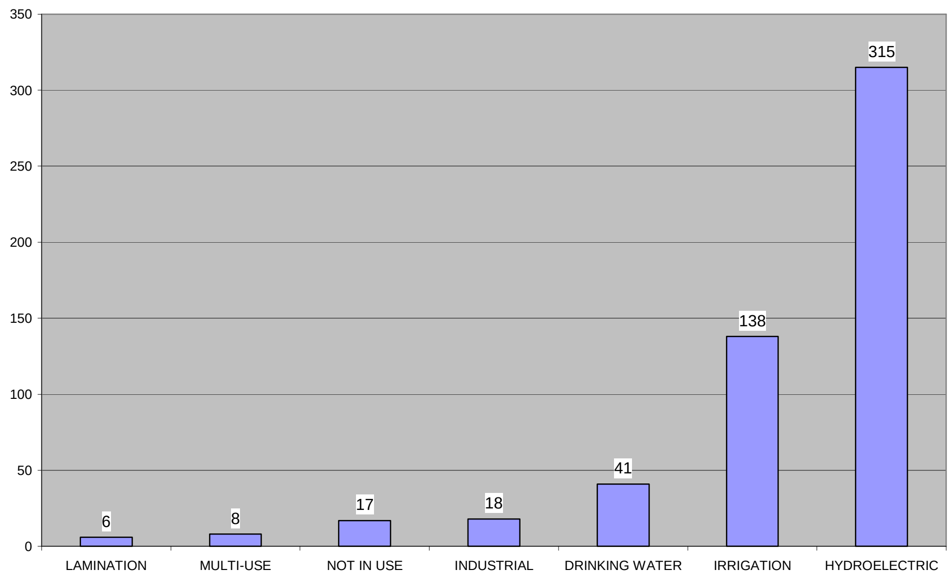


Fig. 1
Number of large dams by use
*Nombre de barrages pour chaque usage*

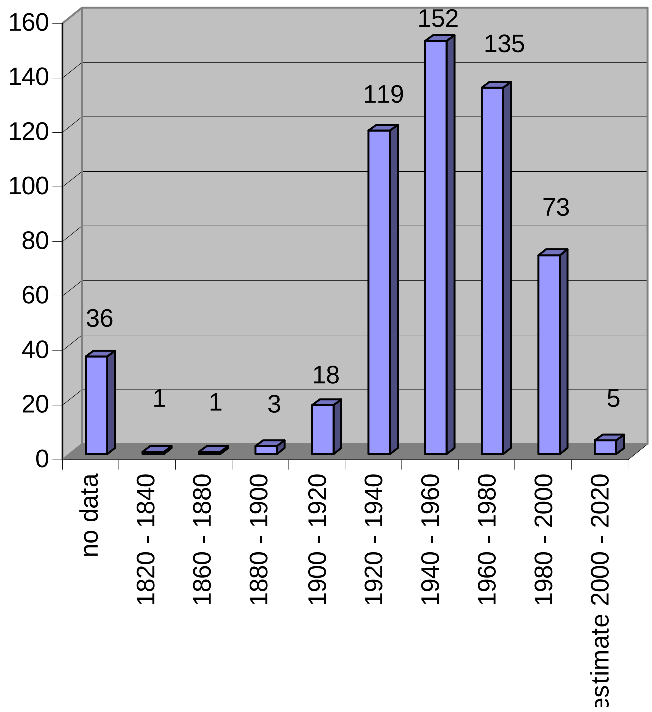


Fig. 2
Construction Time history of large dams in Italy
*Période de construction des grands barrages en Italie*

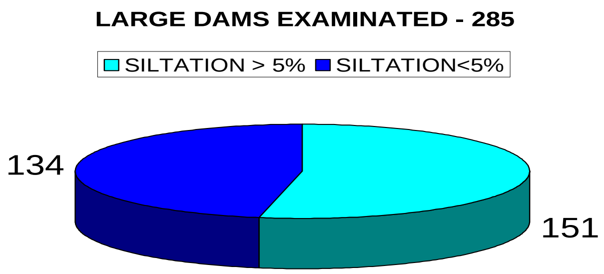


Fig. 3
General summary of silting of the examined Italian reservoirs
*Analyse de la sédimentation dans 285 grands barrages italiens*

Data from two homogenous macro-areas are gathered: The Alpine one covers the northern districts of Italy, whose highest peaks are over 4,000 m (above the medium sea level). The Apennine area develops over the remaining districts dislocated in central and southern Italy, including islands, with peaks lower than 3,000 m a.m.s.l.. Notably, the Alpine chain is mostly constituted of metamorphic and igneous rocks, while the Apennine are made of sedimentary rocks, of the clastic and carbonatic kind.

The silting amount is negligible for reservoirs located at higher elevations, with smaller drainage basins and usually characterized by rocks with low erosion; the silting degree gets instead more pronounced for the reservoirs positioned at lower elevations. Furthermore, it is shown to progressively increase as the watersheds get larger, or if they are characterized by soils and rocks with high erosion. These effects might eventually drive a noticeable decrease of the associated storage capacity of a reservoir, this latter being virtually lost in the most critical cases.

Table 1
Silting of reservoirs – Analysis based on altitude and macro-areas
*La sédimentation dans les grands barrages : Analyse en fonction des régions et de l'altitude*

| Macro Areas | Elevations m a.m.s.l. | EXAMINED RESERVOIRS | SILTATION>5% | | | SILTATION< 5% | |
|---|---|---|---|---|---|---|---|
| | | Numbers | Reservoirs Numbers | Storage capacity $m^3$ | Lost capacity $m^3$ | Reservoirs Numbers | Storage capacity $m^3$ |
| ALPS | >2000 | 26 | 3 | 4,40E+07 | 4,67E+06 | 23 | 2,65E+08 |
| | >1000 | 47 | 16 | 1,22E+08 | 1,32E+07 | 31 | 4,18E+08 |
| | <1000 | 50 | 38 | 3,33E+08 | 7,41E+07 | 12 | 3,31E+08 |
| APPENNINES | >1000 | 16 | 8 | 4,18E+08 | 3,37E+07 | 8 | 1,61E+08 |
| | <1000 | 146 | 86 | 3,84E+09 | 2,11E+09 | 60 | 1,44E+09 |
| **TOTAL** | | **285** | **151** | **4,75E+09** | **2,24E+09** | **134** | **2,62E+09** |

First of all, it has been found that almost half of the reservoirs (47%) are devoid of noticeable silting.

For the silted ones (53%), an average reduction of a storage volume is detected and quantified in 47%.

A more detailed analysis allows to conclude that:

- *As the Alpine macro-area is concerned:*
  88% of reservoirs over 2,000 m is devoid of silting
  66% of reservoirs between 1,000 and 2,000 m is devoid of silting
  making reference to the reservoirs under 1,000 m, only the 24% is devoid of silting

- *With reference to the Apennine macro-area*
  50% of reservoirs between 1,000 and 2,000 m is devoid of silting
  only 41% of the reservoirs under 1,000 m, is devoid of silting

To complete the analysis, a curve of frequency is traced below: on the vertical axis the graph displays the number of reservoirs belonging to the macro areas examined (Alpine and Apennine); on the horizontal axis the corresponding volume's reduction expressed as a percentage are displayed.

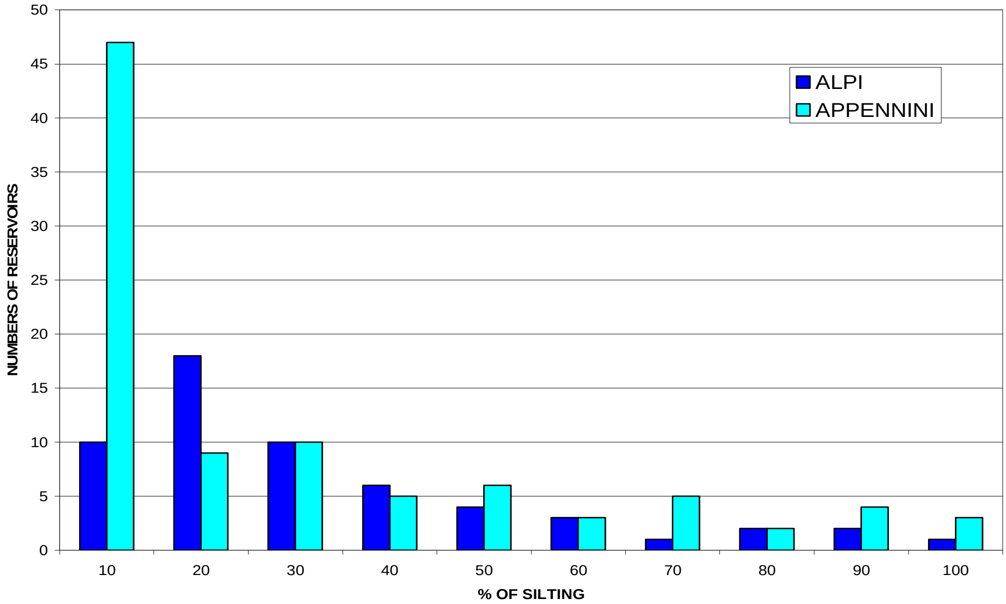


Fig. 4
Frequency of silting percentage for the examined reservoirs
*Fréquence du pourcentage de sédimentation dans les barrages examinés*

Based on the examined sample, which amounts to about 52% of the reservoirs of Italian large dams, a total reduction of the storage volume of 30% has been estimated (2,24E+09/(4,75E+09+2,62E+09)). Extending such an estimate to the ensemble of Italian reservoirs, it results in a total loss of storage capacity of about 4 $km^3$ (30% of 13,35 $km^3$).

## 3. EVOLUTION OF LEGISLATION ON THE MANAGEMENT OF SEDIMENT AND ITS CONSEQUENCES FOR THE MANAGEMENT OF RESERVOIRS

Until the 70's, reservoirs were periodically emptied to facilitate the purging of sediment and their downstream flushing. This operation was usually possible for many Italian reservoirs, considering their rather small dimensions. This allowed to limit the silting process over time.

In 1976 the Law No 319, intended to regulate industrial discharges, was enacted. Law enforcement was based on threshold values defined for several chemical-physical parameters of the discharged flow. Due to a restrictive interpretation of the law, also discharges from dams were treated as industrial discharges and a limit value of turbidity of 80 mg /l was prescribed. This limit was incompatible with the values that usually occur both during the natural flood and during flushing operations. As a result, the most of dam owners, stopped the flushing operations in order to avoid sanctions.

This practice, which was applied for more than twenty years, produced an uncontrolled increase of silting condition. A reduction of the original storage capacity of more than 50% occurred in 36 over 285 examined reservoirs (see Fig. 4). Furthermore, in some reservoirs the bottom outlets resulted completely or partially blocked and buried by sediments. As a consequence, the national Dam Authority imposed in some cases heavy limitations of max allowed reservoir level.

The Decree n.152 issued in 1999 finally admitted that the evacuation of sediments through the bottom outlets should not be treated as industrial wastes and that it is necessary to assure the functionality of the bottom outlets.

The subsequent Decree issued on June 30, 2004 defined the criteria to be followed for the preparation of the “Reservoir Management Report”.

This Report must contain the results of surveys-investigations-measurements carried out on the catchment area, on the reservoir, on the sediment. On the basis of this information the opening operations of bottom outlets valves for the evacuation of sediment are planned. The Report must also define specific protection measures of the ecosystem, both upstream and downstream the dam.

According to the 2004 Decree, reservoirs must be returned to the State at the end of the concession with the original storage capacity. The previous law (1933), required only that works must be returned to the State in a condition of "regular operation"; a reservoir could be returned even silted, provided the regular operation of the bottom and intake works are satisfied. It should be noticed that in many cases the economical cost of the current Law prescription is not supported by the real dimensions of the related business, so that many installations are destined to stop operations.

Moreover, in case of a heavy solid transport of the river, removing sediment from the reservoir would be an effort without end. In such cases, the river will fill the reservoir again in the same time required for the removal of sediments, as highlighted in the Quarto reservoir, subsequently illustrated.

Even if operations to remove sediments by purging/flushing/etc. are in principle currently allowed, in practice, since 2004 only occasional, “experimental” interventions of small importance have been carried out. This is due to the very complex and difficult approval process (by local Authorities Regions and Provinces) of the “Reservoir Management Reports”, in absence of any technical guidelines, strongly wished but not yet available.

The local Authorities, are therefore forced to very conservative approaches, imposing very heavy obligations and limitations (for example, on maximum allowed turbidity values).

Another negative aspect is the fact that the approval of the “Reservoir Management Report” resulted “necessary but not sufficient” for the practical actuation of the works, being the approval of many other agencies acting on the territory still required.

In conclusion, despite the increase of awareness, produced by the Law 152/1999, appropriate technical reference standards are not yet available, this making the approval process of any works devoted to the removal of sediment very troublesome.

# 4. ESTIMATED COST DUE TO LOSS OF STORAGE CAPACITY

## 4.1. ESTIMATED COSTS DUE TO LOSS OF USE OF WATER RESOURCES

Presence of silting sensibly reduces the possibilities of exploiting the storage, a fact which causes an economical loss. In case of reservoirs devoted to water supply the reduction of storage due to silting leads to a loss of production, which do scale proportionally.

For the hydro-electrical storages, instead, one needs to distinguish between run-of-river plant and plant with storage:

- in the first case the reduction of the storage volume due to silting does not cause consequences for the hydro-electrical production
- in the second case the loss of storage does not determine noticeable reduction of the total energy production; whereas it intervenes on the production of valuable energy (peak hours energy), reducing it in a way which is approximately proportional to the decrease of storage volume.

Generally, hence, the effect on the production of electricity is less than proportional to the reduction of storage capacity.

On the basis of the data available for the examined 285 Italian reservoirs, taking into account their various purposes, a production loss per year of about 300 millions of Euro (450 millions of $) is estimated, due to the current reduction of storage capacity.

In particular, as regards the irrigation purpose, the reduction in storage capacity results in a corresponding reduction of the irrigated area of about 500,000 hectares.

## 4.2. ESTIMATED COSTS DUE TO THE RECOVERY OF THE LOST STORAGE CAPACITY

Referring to the previous evaluation of the total silting in the Italian reservoirs, amounting to about 4 $km^3$, the Authors propose in the following a rough estimate of the costs for a complete removal of the sediments. Notice that this estimate is relevant only to the actions required for the removal of sediments according to the current regulation (DM 30 June 2004).

To obtain a sound estimate, few simplifying hypotheses are to be put forward, which set aside the actual feasibility of the interventions (replacement of sediments, availability of water, etc.):

- 30% (1,200 $hm^3$), is removed by flushing; considering an overall average turbidity of 4-5 g/l, this operation requires a water consumption of 500,000 $hm^3$ with a production loss valued more than 40,000 M€ (60,000 M$);
- 20% (800 $hm^3$) is valuable material (sand and gravel) mostly reusable, removable only at digging cost (5 €/$m^3$,7,5 $/$m^3$); the additional costs for transportation, washing and selection is roughly equal to the market value of the material. The total cost is then estimated in 4,000 M€ (6,000 M$).
- 16% (640 $hm^3$), inert material, is removed by in water dredging, dried and placed in dump in proximity of the reservoir, with an unitary average cost of about 28 € (42 $) and a total cost of about 18,000 M€ (27,000 M$); This operation is considered devoid of effects on the production.
- 30%, (1,200 $hm^3$), inert material, is removed by dry digging with mechanical means and placed at dump in proximity of the reservoir, with an unitary average cost of 25 € (37.5 $) and a total cost of about 30,000 M€ (45,000 M$), of which about 10,000 M€ (15,000 M$) due to loss of production
- 4% (160 $hm^3$), polluted material, is assigned to special dumps or made inert at an unitary cost of 176 € (264 $) for a total of 28,000 M€ (42,000 M$), of which about 4,000 M€ (6,000 M$) due to loss of production.

On the basis of these hypotheses, the total cost for removing the 4,000 $hm^3$ currently accumulated in the Italian reservoirs would amount to about 120,000 M€ millions of Euro (180,000 M$ millions of dollars)!

Of these, 55%, are removal costs and 45%, stand for the related loss of production.

Besides valuable material which practically do pay for itself, it is hence clear that among all removal operations the flushing is not the less expensive due to the consumption of water and the related loss of production. Compared to the costs of flushing:

- the in water dredging costs about 84 %
- the dry digging costs about 75%
- the relocation of polluted material costs more than 5 times.

It should be also emphasized that the above evaluation for the production loss merely returns an average reference value for all the Italian large dams , as each single case would prove peculiar, being strongly dependent on the specific situation.

Neglecting the production loss, dredging operations cost about 1.7 times the dry digging.

Finally, the impact of the costs of the various operations on the total charge is distributed as follows:

Table 2
Impact of the costs of the various operations on the total charge
*Impact des différents coûts pour le déplacement des sédimentes*

| Method of removal | Impact on quantity % | Impact on cost % |
|---|---|---|
| Flushing | 30 | 34 |
| Dug valuable material | 20 | 3 |
| Inert material with in water dredging | 16 | 15 |
| Inert material with dry digging | 30 | 25 |
| Polluted material relocated to dump | 4 | 23 |

## 5. CASE HISTORIES

### 5.1. TIME EVOLUTION OF SILTING IN QUARTO RESERVOIR

The Quarto dam, built in 1925, is situated in proximity of the town of Forlì (centre-north of Italy), at an altitude of about 310 m a.m.s.l. Its catchment area is 215 km$^2$. The solid transport in the Quarto reservoir is so heavy that any effort to remove the sediment would last shortly so that it becomes an endless effort.

The heavy solid transportation is alimented by marl and sandstone rocks, easily erodible and constituting the main part of the catchment area. The silting of the reservoir come to progressively fill various zones of the lake, favouring the growth of a very thick marsh vegetation, and various arboreal species.

Since 1925 many surveys have been carried out to study the solid transport and reservoir silting. In table 3 and fig. 5 data relevant to the silting process are reported. The most recent data (2006) point out that the reservoir has lost 97% of its original storage capacity.

Confronting the values of maximum depth for a certain number of sections along the branches of Savio and Para rivers, during the time span from 1925 to 2006, it can be noticed that the bottom in proximity of the dam progressively rose until 2006. In the branches, instead, the rising was evident until the 1995 survey, while the depth grew again between 1995 and 2006.

This is probably the consequence of the progressive morphological modifications of the basin, which in the higher part has slowly changed into a river bed, the flowing tending therefore to erode the bottom, when free to run. On the contrary, in the lower part, slowed by the dam, the basin still determines silting events.

Table 3
Variation of storage capacity with time
*Évolution du volume disponible*

| Period | Storage Capacity ($m^3$) at 317,8 m m.a.s.l. | Silted Volume partial ($m^3$) | Silted Volume progressive ($m^3$) | % Storage capacity reduction |
|---|---|---|---|---|
| 1925 | 4,543,000 | | | |
| 1933 | 2,183,000 | 2,360,000 | 2,360,000 | 52 |
| 1938 | 1,737,000 | 445,000 | 2,805,000 | 62 |
| 1941 | 1,404,000 | 333,000 | 3,138,000 | 69 |
| 1958 | 617,000 | 787,000 | 3,925,000 | 86 |
| 1995 | 372,000 | 245,000 | 4,170,000 | 92 |
| 2006 | 146,000 | 226,000 | 4,396,000 | 97 |

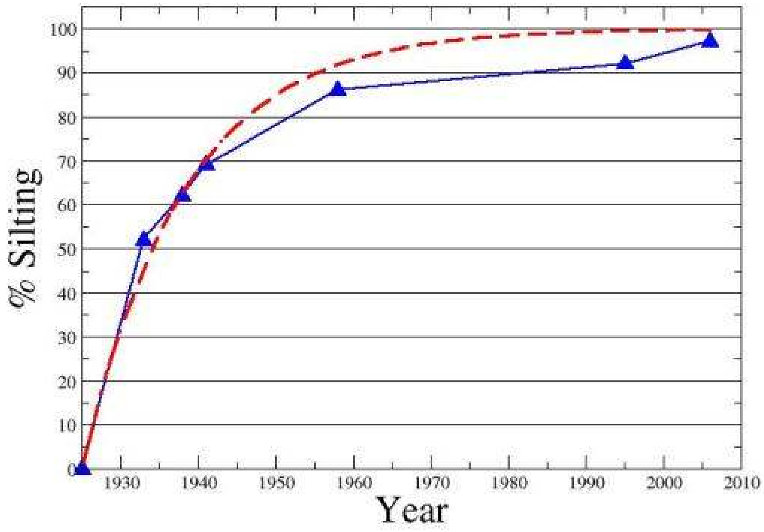


Fig. 5
Evolution over time of Silting for the Quarto dam
*Evolution dans le temps de la sédimentation dans le barrage de Quarto*

In the following table 4 the annual rate of silting is reported.

Table 4
Silted volume and annual rate of silting (decrease of the storage capacity)
*Volume sédimenté et variation annuelle des sédiments*
*(réduction de la capacité de stockage)*

| PERIOD | Silted Volume ($m^3$) | Annual Rate of silting ($m^3$/year) |
|---|---|---|
| 1925-1938 | 2,850,000 | 215,000 |
| 1938-1958 | 1,120,000 | 56,000 |
| 1958-1995 | 245,000 | 6,600 |
| 1995-2006 | 226,000 | 2,200 |

Data show a progressive reduction of the silting growth gradient, confirming the continuously reduced ability of the storage to trap new sediment. The morphology of the storage has by now reached a stable condition, balancing the erosion and sedimentation process. The humid zones filled by cane thickets are areas external to the river bed usually interested by the water flow.

In the described situation, any attempt to remove the sediments and restore the reservoir capacity is judged not to be worthwhile.

## 5.2. EXPERIENCE ON ESTIMATE OF SILTING FOR THE RESERVOIR OF PIANO DELLA ROCCA

The high relevance of reservoirs for hydropower production induced since the ‘30s of the twentieth century, the systematic study and monitoring of silting in many Italian reservoirs (Servizio Idrografico e Mareografico Nazionale, 1960) as well as a monitoring of the suspended load in several Italian rivers. Specific studies were also carried out in the Italian regions where the prevalent outcropping of low permeability terrains had prevented the exploitation of groundwater resources favouring the construction of reservoirs for agricultural and economic development, as in the Basilicata region case. After the construction of the most part of the Italian reservoirs completed in the ‘50s and ‘60s, studies on siltation were especially focused on those critical cases where extreme rate of sedimentation not permitted the planned functioning as for example the cases of the Quarto (Tuscan-Emilian Appennine) and the Rendina (Basilicata) reservoirs in which a sedimentation rate up to $1.6 \times 10^6$ kg / year × $km^2$ has been estimated (Servizio Idrografico e Mareografico Nazionale, 1960). Many other studies about siltation in Italian reservoirs were carried out during management operations that allowed the estimation of sediment volumes after storage emptying and mechanical removal of deposits or by bathymetric surveying.

In order to compare the effectiveness of the methods described in the preceding paragraphs the Authors briefly discuss the results of the analyses carried out for the Management Plan of the Piano della Rocca reservoir [7] in which different methods at intermediate and detailed scale have been applied.

Piano della Rocca is a reservoir of about 30 $hm^3$ located in the upper part of Alento river and subtending a watershed of 102 $km^2$ that is mainly constituted of flysch terrains (90 $km^2$) and subordinately of carbonate rocks (12 $km^2$). After 10 years since the first storage (1995), analyses of silting with different approaches have been carried out. Specifically, during a low stage phase of the water level, the emerged sediment volume has been estimated by means of dynamic penetration tests that allowed the measurement of deposit thicknesses. This experimentation have shown a good applicability of dynamic penetration tests especially whereas a strong mechanical difference exists between soft silted sediments and the underlying harder rocks or soils, such as the original coarse alluvial sediments. The thickness data result to be well correlated with the altitude, namely with the depth from the maximum water level stage. Such observation allow the identification of an empirical relationship that can be utilised for the calculation of the sediments in the surveyed altitudinal range (Fig. 6).

By the comparison of the different results obtained through the application of empirical [6] and semi-empirical methods [17], it has been possible to observe a relevant difference, not exceeding 100%, and a good comparison among methods belonging to the same type (Fig. 7). In particular, the second group estimates greater values than the first one, probably because the first is based only on the suspended load (Tu), being therefore representative of finer grain size fraction. Such discrepancy could be moreover attributed to the representativeness of the suspended load measurements carried out by the ex-National Hydrographic and Tidal Service, that unlikely did not coincide with flood peaks.

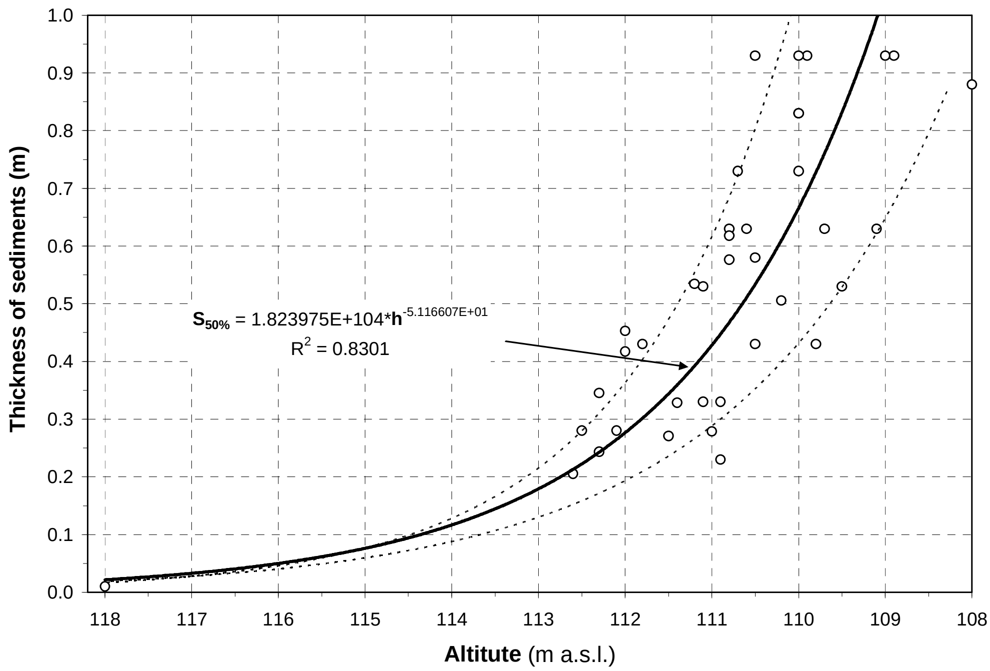


Fig. 6

Empirical relationship between the sediment thickness deposited in the elevation range between the maximum water level, 118.5 m a.m.s.l. and 109 m a.m.s.l.

*Relation empirique entre l'épaisseur de dépôt déposée dans la gamme d'altitude entre le niveau maximal d'eau, 118.5 m a.m.s.l. et 109 m a.m.s.l.*

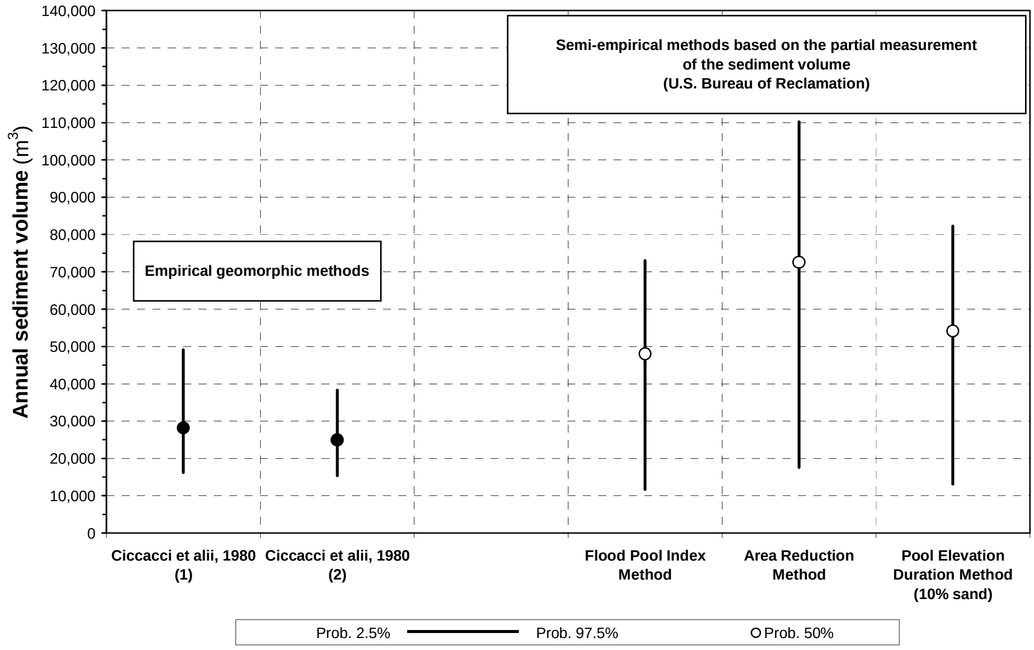


Fig. 7
Comparison among the mean annual volume of siltation obtained by the application of empirical geomorphic methods and semi-empirical methods of U.S. Bureau of Reclamation.
*Comparaison parmi le volume annuel moyen de siltation obtenu par l'application de méthodes géomorphiques empiriques et les méthodes semi-empiriques du U.S. Bureau of Reclamation*

## CONCLUSIONS

On the basis of data relevant to 285 examined reservoirs (more than half of the large Italian reservoirs), it has been estimated a total loss of storage due to silting of about 4,0 km$^3$, almost 30% of the original volume. The loss of storage capacity gives rise to an annual loss of production estimated in about 300 M€ (450 M$), and, as irrigation is concerned, to 500,000 hectares of reduction of the irrigable area.

First of all, it should be noticed that the present level of silting is certainly more important than expected if a dedicated management of the installations would have been systematically undertaken. This situation stems from the laws in force in Italy which, for many decades, have not allowed operators to perform any managing of the sediments. More recently, however, a novel awareness of the problem at hand has been registered, and new laws have been approved which could be in principle instrumental to overcoming the present state of complete inactivity, as determined by the previous provision (Merli's Law).

It should be nonetheless stressed that the preliminary adjustments of the legislations, as in force currently, have not been accompanied by an adequate field activity. It is believed that new activities could receive a marked impulse by a set of technical rules, which would prove effective in assisting both the planning and the execution of sediments managing operations and, moreover, regulating the environmental monitoring. These technical regulations should also support, local technical functionaries, called to authorize and control on field activities. It is also desirable that the functionaries would receive a dedicated training on such specific matters, so that they will not be left solely to act for the bureaucratic management of authorizations.

It is also thought necessary to establish a hierarchical grade in applying the rules, so that to favour the adoption of suitable simplifications in case of less demanding interventions, both from a technical and environmental point of view, or with reference to those operations which involve less relevant dimensions.

Among all possible strategies, the solutions which contemplate releasing the sediments in the river bed should be always preferred, also to favour the re-balancing of the downstream coastal and fluvial dynamics. On the contrary, dumping of sediments removed from the reservoir should be regarded as the last viable possibility, to be adopted only when no other solution is available. As a final remark, it should be considered safe to release the sediments in the river bed when these latter are characterized by an average turbidity index comparable to that detected in presence of natural large flood events.

In Italy, the problem of sediments management has certainly been enhanced by the inadequate laws in force to date and their warped application. Only in the last years the government finally realized past faults in the regulation and consequently promoted new laws, which however are far from being systematically adopted. It is now crucial to take one step forward in the planning of sediments managing activities, aiming for an optimal protection of the structures, namely dams and their reservoirs, which do play a key role in the effort of providing water, destined to inexorably become a more and more precious value.

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## SUMMARY

According to official data published by the Italian Ministry of Large Structures, updated to march 2007, it follows that large dams in Italy are 543, 15 of which are out of operation for technical reasons.

The total storage capacity of Italian large dams is about 13,350 $km^3$; the medium age of Italian large dams is about 66 years.

The total amount of silting of italian reservoirs has been estimated using data from 285 reservoirs, which represent about 52 % of all the Italian large dams and correspond to a water storage capacity of 7,35 $km^3$, thus amounting to about 55% of the total storage capacity.

On the basis of an examined sample which covers more than half of the large Italian reservoirs, it has been estimated a total loss of storage, as determined by silting in all the reservoirs, which totals to 4,0 $km^3$ equalling almost 30% of the original volume. As previously mentioned, the loss of volume gives

rise to an annual loss of production here estimated in about 300 M€, and, as concerns irrigation, results in a 500,000 hectares reduction of the irrigable areas.

Only in the last years the government finally has become aware of past faults in the regulation and consequently promoted new laws, which however are far from being systematically adopted. It is now crucial to take one step forward in the planning of sediments managing activities, aiming for an optimal protection of the structures, namely dams and their reservoirs, which do play a key role in the effort of providing water, destined to inexorably become a more and more precious value. The unique indications of a technical nature are currently supplied by the few regulations issued by some Italian regions (four over twenty). These documents explain, for example, how the impounded water and the sediment should be characterized and how to define the potential destinations of sediments in case of removal are also defined.

To obtain a sound estimate, few simplifying hypotheses are to be put forward, which set aside the actual feasibility of the interventions (replacement of sediments, availability of water, etc.)

Generally, then, in the hypothesised situation the size of the total charge for removing the 4,0 $km^3$ of sediment currently accumulated in the Italian reservoirs would amount to about 120,000 M€. Of these 120,000 M€, about 66,000 M€, equalling 55%, are removal costs and about 54,000 M€, equalling 45%, stand for the associated loss of production. As stated before, the benefit associated with this relevant investment is estimated in 300 M€/year, obviously the economic return on investment is extremely inconvenient and therefore is imperative considering the feasibility and cost effectiveness for each individual case. It was shown that the complete recovery of storage capacity of Italian reservoirs as required by current applicable law is heavily unprofitable.

In order to give an example of the effectiveness of the methods described in the preceding paragraphs the Authors briefly discussed two case histories: the results of the analyses carried out for the editing of the Reservoir Management Report of the Quarto dam and of the Reservoir Management Report for the Piano della Rocca dam.

## RÉSUMÉ

D’après les données officielles publiés par le Ministère des Infrastructures, mises à jour en mars 2007, il en résulte l’existence de 543 grands barrages en Italie, dont 15 hors exercice pour des raisons techniques.

Le stockage total des barrages italien s’élève à 13.35 $km^3$ environ; l’âge moyen de ces barrages est de 66 ans.

L’envasement totale des retenues italiennes a été estimé utilisant les données de 285 retenues, égale au 52% du total, et correspondent à un stockage de 7.35 $km^3$, égale au 55% du stockage total.

Utilisant les résultats de cet échantillon qui représente plus de la moitié des barrages italiens, on a estimé une réduction de la capacité totale de stockage, due à l’envasement, de 4 $km^3$, égale au 30% du volume originaire. Comme dit auparavant, cette perte de capacité se traduit dans une perte de production estimé à 300 M€ et, pour l’irrigation, une réduction de 500,000 ha irrigables.

Seulement dans les dernierès années le gouvernement a pris acte des défauts des règlements existants, et en conséquence a promulgué de nouvelle lois, qui ne sont pas encore mises en œuvre systématiquement.

C’est pourtant nécessaire d’avancer dans la planification de la gestion des sédiments, visant à une protection optimale des structures qui jouent un rôle clé dans la gestion de l’eau, destinée inexorablement à devenir une ressource de plus en plus précieuse .

Les seules indications techniques sot maintenant fournies par les peu de règlements émis par quelque région (4 sur 20). Ces règlements indiquent, par exemple, comment devrait être caractérisé la qualité de l’eau et de sédiments; aussi la possible destination des mêmes dans le cas d’enlèvement.

Pour obtenir une bonne évaluation, ou a utilisé quelques hypothèses simplistes, et qui ne considèrent pas la possibilité réelle d’effectuer les interventions (enlèvement des sédiments, disponibilité d’eau, etc.)

En ligue générale, suivant les dites hypothèses le coût total pour enlever les 4 $km^3$ de sédiments, s’élèverait à 120,000 M€ environ; à savoir 66,000 M€ (55%) pour les coûts d’enlèvement et 54,000 M€ (45%) pour les pertes de production associés.

Comme déjà dit, le bénéfice estimé de cet investissement très importante est évalué à 300 M€ par an ; évidemment le retour économique est trop faible et pour cela il devient impératif d’analyser la faisabilité et le retour économique pour chaque cas. Il reste prouvé que la récupération totale du stockage des retenues italiennes, comme demandée par la loi, est lourdement passifs.

Pour donner un exemple de l’efficacité des méthodes indiquées, nous illustrons deux études de cas ; les résultats des analyses effectuées pour la préparation des Rapports pour la gestion de la retenue soit pour le barrage du Quarto que pour le barrage de Piano della Rocca.