Water and sediment retention in a reservoir (Zit Amba, Algeria)

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Abstract. This work assesses surface water, sediment and salts budget for Zit Amba dam (storage capacity 120 million m^3) in the Kebir West catchment (1 900 km^2; North Eastern Algeria), and the fluxes into the adjacent coast through the Kebir West river' outlet. The catchment is weakly populated with only 30 people km^{-2}, where the agricultural practices are becoming more intensive. The total suspended solids (TSS) and total dissolved solids (TDS) were measured twice a month during April 2012-March 2013 at the entrance and exit of the dam and at the River' outlet. Zit Amba dam seems to be affected by sediment sinking, and is thus submitted to severe and rapid clogging. The dam received annually about 9 000 tons of TSS and trapped an amount of 3 000 tons. This represented a retention rate of 67% of the receiving sediment masses. Annual retention of TDS in the dam is in the order of 100 000 tons (50%). The sediment yield reached a value of 20 t km^2 yr^{-1} for Zit Amba sub-basin. At the catchment outlet, the Kebir West outlet delivered 6 000 t yr^{-1} of TSS and 472 000 t yr^{-1} of TDS. This is equivalent to 4t km^2 yr^{-1} of sediment and over 325 t km^2 yr^{-1} of salt yield.
Key Words: catchment, Kebir West River, dam, sediment TSS, TDS.

Introduction. Rivers are the most important freshwater resource for humans. Social, economic and political development has, in the past, been largely related to the availability and distribution of fresh waters contained in riverine systems (Meybeck et al 1992). The rivers play a particular role in supporting the Mediterranean production whose most productive zones are limited at the adjacent coast (Friedl et al 2004; Teodoru et al 2006). Rivers play an important role in the global biogeochemical cycles by transferring dissolved and particulate substances from land to sea. By creating reservoirs in rivers, humans are substantially impacting the flux of sediments, organic matter and nutrients to the coastal zone (Vörösmarty et al 2003). To meet the growing water needs, numerous dams have been built all around the Mediterranean Sea (Lehner et al 2011). Changes in water quality of rivers due to the construction of dams have been recorded in literature (Petts 1984; Hart et al 1991). Dams may have a strong impact on the water and nutrient river discharge due to silicate (Si) and phosphorus (P) retention within sediments (Aviles & Niell 2007; Dürr et al 2011).

The climatic variability will increase, resulting in greater frequency and intensity of extreme weather events, which could increase, as a consequence of global climate change (Nunes & Seixas 2003; Nearing et al 2005). Soil erosion rates may be expected to change in response to changes in climate for a variety of reasons, the most direct of which is the change in the erosive power of rainfall (Favis-Mortlock & Savabi 1996; Williams et al 1996; Favis-Mortlock & Guerra 1999; Nearing 2001; Pruski & Nearing 2002). Soil erosion responds both to the total amount of rainfall and to differences in rainfall intensity, however, the dominant variable appears to be rainfall intensity and energy rather than rainfall amount alone (Nearing et al 2005). The changing precipitation pattern, and its impact on surface water resources, is an important climatic problem facing society today (De Luis et al 2000). This could be especially relevant in Mediterranean catchments where precipitation is characterized by scarcity, heavy spring and autumn storms, despite the large spatiotemporal variability (Ulbricha et al 2012). It has been reported that changes of water discharge and sediment load can cause various effects on river system itself as well as the estuary and coastal shelf environment (Zhang et al 2007). Chen (2000) pointed out that changes of river inputs (mainly water flow, sediment load as well as nutrient flux) to the oceans caused by river basin development, notably the construction of dams, have more subtle effects which go far beyond the delta and estuaries including the transformation of the coastal shelf ecosystem and the starvation of fish populations. The importance of fluvial sediment to the quality of aquatic and riparian systems is well established (Gray et al 2000). The sediment as the single most widespread cause of impairment of the Nation's rivers and streams, lakes, reservoirs, ponds, and estuaries were identified by Parry (1998) and Gray et al (2000). Rates of erosion are associated with climate, particularly the amount and intensity of rainfall, and can be modified by vegetative cover (Meybeck et al 1992). Rivers represent an important link between land and the ocean, and presently, they annually discharge about 35 000 km^3 of freshwater, and 22 109 tons of solid and dissolved materials to the ocean (Milliman & Farnsworth 2011). The transport of river borne sediment from the continental land mass to the world's oceans is a fundamental feature of the geology and biogeochemistry of our planet (Vörösmarty et al 2003).

Several studies (Milliman 1997; Walling 2006; Ludwig et al 2009) noticed that both water and sediment discharge of several world's rivers have shown progressive decrease during the last 50 years, which is more primarily due to reservoir construction, water abstraction, and soil conservation. Generally, the decrease of sediment load was reported (Zhang et al 2007) to coincide with decreasing trends of some major ions and total dissolved solids (TDS or salts).The dams are trapping a large portion of the sediments, which in turn may decrease the biological productivity as parts of nutrients are attached to the sediment (Taamallah et al 2016). In the Mediterranean basin, the information on water erosion is still scarce (Meybeck & Ragu 1996) and particularly lacking in Algeria coastal basins (Benblidia 2011; Remini 2010). The erosion rate of several Algerian dams had been however assessed by Touaibia (2010), but had not considered the amounts of sediment delivered from the dams' exits. In three dams belonging to North Eastern coastal catchments the sediment and salts budget had been however assessed by Bouchareb (2013). This work challenges to assess surface water, sediment and salts budget for Zit Amba dam in the Kebir West basin. The aim of this study is also to determine water, sediment and salts fluxes into the adjacent coast through the Kebir West catchment outlet.

Material and Method

Sampling site. Dam of Zit Amba (wilaya of Skikda) was recently built, knowing that this dam currently feeds the chief place of the wilaya as well as the daïra of Azzaba (Harrat & Achour 2011), that situated in Kebir West catchment occupied an area of 1 900 km^2 (Figure 1), but very weakly populated, with only 30 people km^{-2}. The downstream part of the basin of the reservoir is located in the wilaya of Skikda, the central and upstream parts are in the wilaya of Guelma (Harrat & Achour 2011). Zit Amba (120 million m^3 storage capacity) reservoir is used for irrigation and drinking water. Zit Amba reservoir is fed by two tributaries of Kebir West stream, with Oued El hammam at the south and Oued Mechekel at the west. Oued El hammam is submitted to some urban pollution sources and hydrothermal used water, but Oued Mechekel delivers however more clean waters (Figure 1). The surface area of the dam basin is 485 km^2, with a triangular compact shape (Belhadj et al 2011). The average annual temperature is 17 to 18°C, with annual rainfall of about 700 mm, which is relatively large, variable and irregular from one year to the next (Belhadj et al 2011). In summer, the two branches fall almost dry at the entering of Zit Amba reservoir, but its exit extruded low amounts to entertain some agricultural and stream environmental services. The water residence time (storage capacity/discharge (Ounissi & Bouchareb 2013) of the studied reservoir is largely variable according to the stream input, storage capacities and clogging rates. In 2012, the water residence reached 4 months. This is 7 folds lower than the residence time reported by Ounissi & Bouchareb (2013) in 2010.

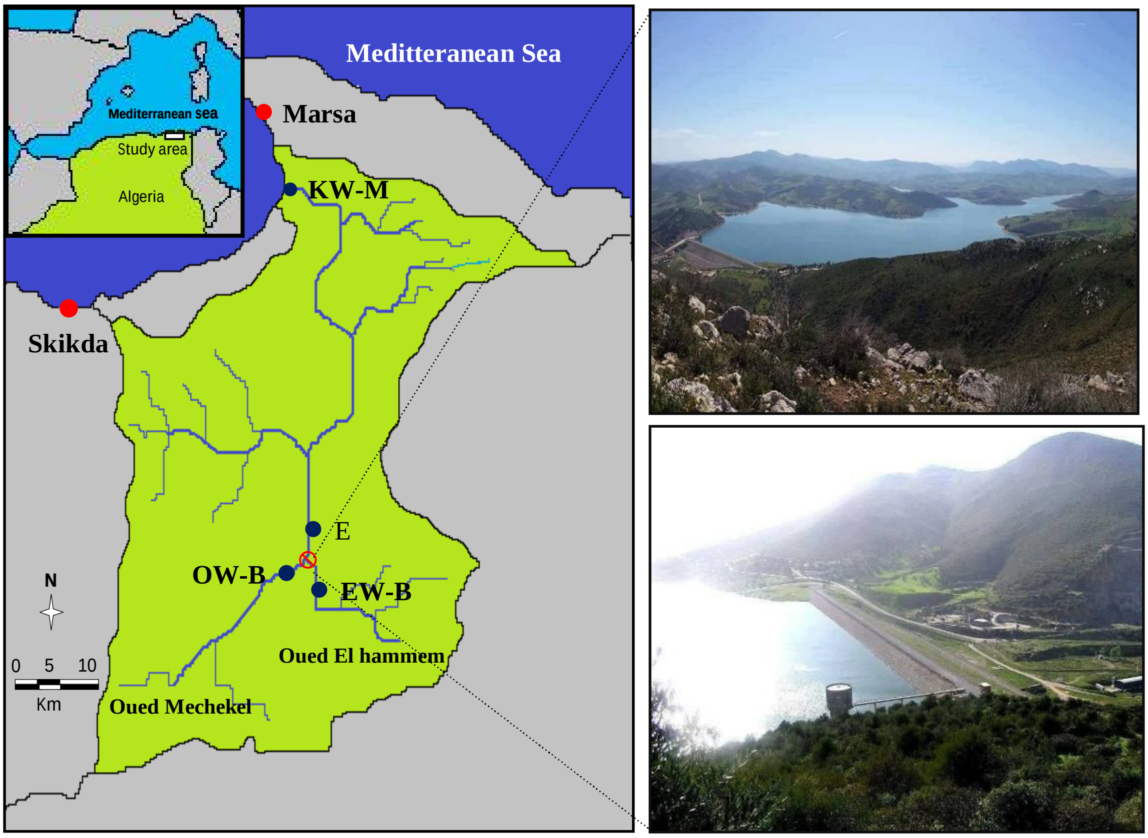

Figure 1. Study area and location of sampling stations. ⊘: Zit Amba reservoir; E-WB: entrance of Oued El Hammam branch; OW-B: entrance of Oued Mechekel branch; E: the exit and Zit Amba reservoir. KW-M: the mouth of Kebir West. On the right are views of Zit Amba dam.

Analytical methods. Jointly to water sampling, the flow velocity ($m^3\ s^{-1}$) of the stream was assessed by the current meter CM-2 (Toho Dentan Co. Ltd, Tokyo). The flow ($m^3\ s^{-1}$) was computed by multiplying the water velocity by the total surface area (m^2) of the streams' transect. The water flow, total suspended solids (TSS) and TDS were monthly measured during April 2012-March 2013 in 2 stations for Zit Amba reservoir (Figure 1) and 1 station for Kebir West catchment. Stations were located at the entrance and exit of Zit Amba dam and at the outlet of the Kebir West catchment (Figure 1). Measurements of water velocity were taken at several points depending on the station section size and depth. The TDS were measured (in milligram per liter or $mg\ L^{-1}$) in situ with the WTWi197 Multiparameter. In the laboratory the TSS were measured following the method described in Aminot & Chaussepied (1983). Two subsamples of 500 mL were filtered on pre-combusted (450°C for 1 h) and pre-weighed Whatman GF/C glass filters for TSS weight measurements. These filters were dried at 110°C for 1 hour by an oven dryer and then weighed with a Metler microbalance which provides a precision of 0.10 mg. For each filter, the TSS was obtained by subtracting the final filter weight (filter + TSS) from the initial weight of the filter, and the results were expressed in milligram per liter ($mg\ L^{-1}$). The instantaneous and annual TSS and TDS fluxes were assessed using the method of average instantaneous loads (Preston et al 1989).

Results

Water discharge into and from the Zit Amba dam and into the sea from the Kebir West outlet. The precipitation over Zit Amba sub-catchment reached 700 mm (Table 1). Water flow at the entrance of Zit Amba dam varied largely between 0.5-88.50 $m^3\ s^{-1}$ with an average of 12.1 $m^3\ s^{-1}$, corresponding to 376.5 $10^6\ m^3\ yr^{-1}$. Zit Amba dam delivered between 0.3 and 14.6 $m^3\ s^{-1}$ and had an average of 7.8 $m^3\ s^{-1}$, equivalent to 242.2 10^6

$m^3\ yr^{-1}$ (Table 1, Figure 2). Considering the received water discharge, Zit Amba reservoir seems to renewed every 4 month (residence time 4 month) (Table 1).

Table 1

Hydrological parameters of dam and river outlet studied during the study period (April 2012-March 2013)

			Catchment area (km^2)	*Dam capacity ($10^6\ m^3$)*	*flow ($m^3 s^{-1}$)*	*Volume* ($10^6 m^3\ yr^{-1}$)*	*Residence time (month)*	*Rainfall (mm)*
Dam sub-basin	Zit Amba dam	Entrance	450	120	12.1	376.5	4	700
		Exit	450	120	7.8	242.2	4	700
Lower KW catchement	KW outlet	outlet	1 450	-	12	386.1		742

* Volume of water received and delivered by the dam during the study period.

Water flow from the Kebir West outlet varied between 2 and 33 $m^3\ s^{-1}$ with an average of 12 $m^3\ s^{-1}$ (Figure 2) corresponding to an annual discharge of 386 $10^6\ m^3$. During the dry period extending from May to August, the annual average of flow in the entrance in the entrance was 3.88 $m^3\ s^{-1}$ and 8.7 $m^3\ s^{-1}$ at exit due to the opening of the dam during this period. The outlet had received large freshwater amount during the wet season, reach 318.5 $10^6\ m^3$.

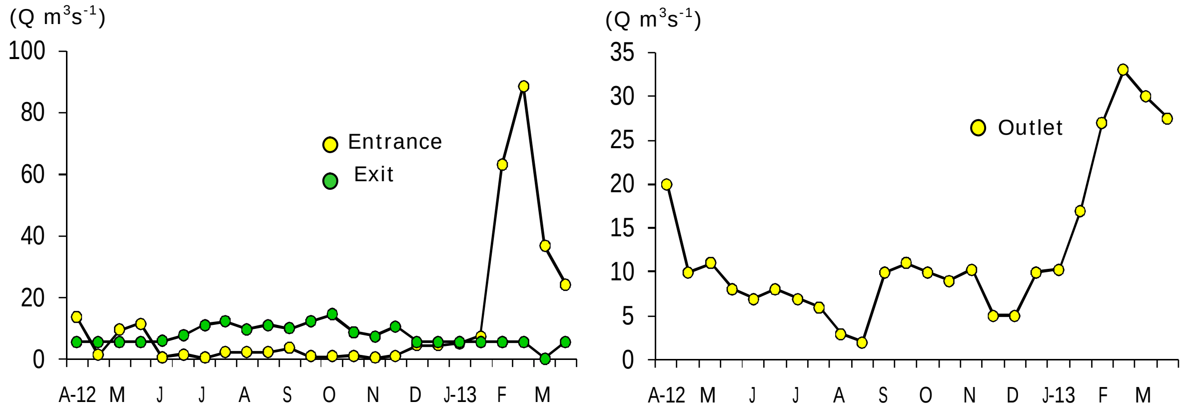

Figure 2. Water discharge ($m^3\ s^{-1}$) at the dam entrance and exit of Zit Amba dam and at the Kebir West outlet during the Study period (April 2012-March 2013).

TSS and TDS level entrance and exit the dam and at the Kebir West outlet. The TSS levels of waters entering Zit Amba dam varied largely (4.3-66.3 mg L^{-1}) with an average of 16.7 mg L^{-1}. During the wet period TSS average amounts increased to reach 21.8 mg L^{-1} as can be seen in Figure 3. At the entrance of Zit Amba dam, the TDS levels ranged between 257.8-1.298 mg L^{-1} (Figure 3). In contrast to TSS seasonal cycle, TDS levels decreased to 547.9 mg L^{-1} during the wet period, but increased to 707.3 mg L^{-1} in the dry period. Water exiting Zit Amba dam were lowered by 35% in TSS levels and 30% in TDS levels, compared to the incoming amounts.

At Kebir West outlet the average annual level of TSS was 12.4 mg L^{-1}. The maximum value (15.7 mg L^{-1}) was recorded to the wet period and decreased to 5.87 mg L^{-1} in the dry period (Figure 3). This is because of sediment supply from agricultural lands, which spreads over the lower catchment, and is usually amended in winter, coinciding with the wet period.

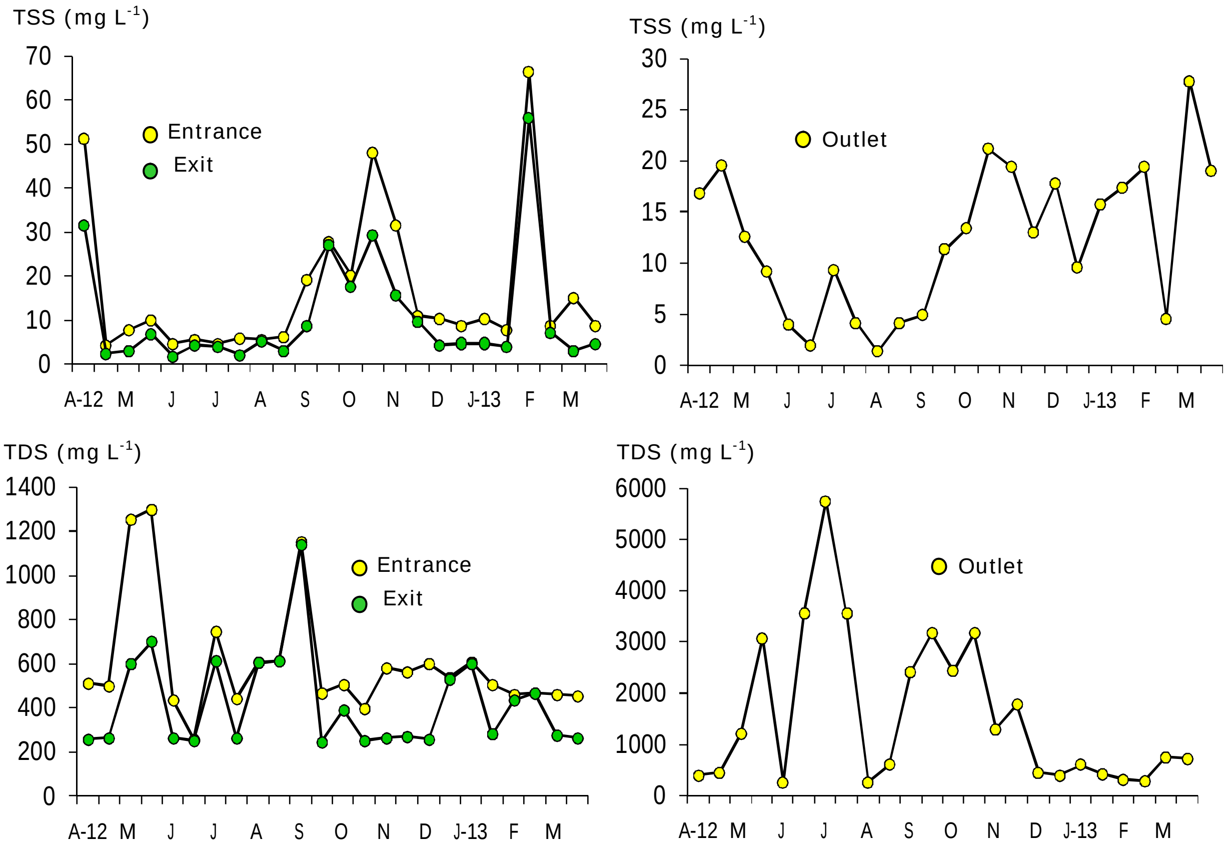

Figure 3. TSS and TDS levels (mg L^{-1}) at the dam entrance and exit and at the Kebir West outlet during the Study period (April 2012-March 2013).

TSS, TDS fluxes into and from the dam and at the Kebir West outlet. The delivered water into the Zit Amba dam brought annually 9 000 tons of suspended sediment, from which 67% (6 000 tons) is lost to the dam (Table 2). The erosion rate was 20 t km^2 yr^{-1} in sub catchment and 4 t km^2 yr^{-1} in the outlet during the study period. This difference is mainly due to the large amount of water discharge from the upstream of Zit Amba dam, and the exceptionally elevated rainfall height during the study period. The dam received annually 207 000 tons of dissolved solids, from which 49% (101 000 tons) is trapped (Table 2). The Kebir West outlet delivered annually to the sea 472 000 tons of TDS, and about half this amount resulted in dam release. The Zit Amba dam and the lower catchment have elevated soil degradation, as the specific salt losses reached in average about 325 to 460 t km^2 yr^{-1} (Table 2).

Table 2

Fluxes (t yr^{-1}) and specific fluxes (t km^2 yr^{-1}) of TSS and TDS from and into the dam and at the outlet during the study year (April 2012-March 2013)

		TSS (10^3t yr^{-1})	*TSS (t $km^2 yr^{-1}$)*	*TDS (10^3t yr^{-1})*	*TDS (t km yr^{-1})*	*TSS/TDS*
KW Dam	Entrance	9	20	207	460	4.34
	Exit	3		106		2.83
	R %	67		49		
KW River	Outlet	6	4	472	325	1.27

KW - Kebir West.

Discussion. The transfer of the dissolved and suspended solids across the aquatic continuum of the Kebir West catchment, from entrance the dam up to the catchment outlet was assessed in this study. The dam has received about 376.5 million m^3 of freshwater over the study year. The Kebir West outlet discharged into the sea 386.5 million m^3. The entrance of Zit Amba dam was heavily charged in TDS and weakly charged in TSS. As they were largely trapped in the dam, the sediment and salts amounts were remarkably reduced downstream the dams. The removal of sediment reached 67%, but retention of salts by Zit Amba was 49% (101 000) tons. In three dams (NE Algeria), Bouchareb (2013) reported more elevated sediment retention (70-92%) and salts retention (50-90%). Because of climatic and geologic factors, Algerian surface waters are known to be more salty than those of northern Mediterranean countries (Aubert 1976). Zit Amba dam trapped annually over 6 000 tons of TSS. Zit Amba dam seems thus to be affected by sediment deposition, and it is thus being submitted to severe and rapid clogging. Similar sedimentation was reported for Zerdaza dam, built on a contiguous Algerian catchment (Remini 2010; PNUE/PB 2003). The sediment loss reached a value as low as 20 t km^2 yr^{-1} for Zit Amba sub-basin. Sediment yields are highly variable in Algerian and Mediterranean coastal catchments and their dams (40-2780 t km^2 yr^{-1}) as shown in Table 3.

Table 3

Sediment loading (TSS, t km^2 yr^{-1}) for some Mediterranean and Algerian rivers and dams

River/dam opening	*t km^2 yr^{-1}*	*References*
Mediterranean rivers	251	UNEP/MAP/MED POL (2003)
Ebro River, Spain	214	UNEP/MAP/MED POL (2003)
Têt stream, France	40	Serrat et al (2001)
Rhône river, France	324	Pont et al (2002)
Italian rivers	780	UNEP/MAP/MED POL (2003)
Greece rivers	1140	UNEP/MAP/MED POL (2003)
Albanian rivers	2780	UNEP/MAP/MED POL (2003)
North African catchments	800	Fox et al (1997)
Maghreb catchments	397	Probst (1992)
Majrda, Tunisia	963	UNEP/MAP/MED POL (2003)
Moulouya, Morocco	250	UNEP/MAP/MED POL (2003)
Nile, Egypt	42	UNEP/MAP/MED POL (2003)
Cheliff, Algeria	78	UNEP/MAP/MED POL (2003)
Isser, Algeria	193	UNEP/MAP/MED POL (2003)
Kebir west, Algeria	200	UNEP/MAP/MED POL (2003)
Seybouse, Algeria	333	UNEP/MAP/MED POL (2003)
Soummam, Algeria	513	UNEP/MAP/MED POL (2003)
Tafna, Algeria	143	UNEP/MAP/MED POL (2003)
Cheffia dam, Algeria	2700	Touaibia (2010)
Charf dam, Algeria	300	Touaibia (2010)
Beni-Haroun dam, Algeria	64	Bouchareb (2013)
Zit El-Amba dam, Algeria	374	Bouchareb (2013)
Zerdaza dam, Algeria	192	Bouchareb (2013)
Chaffia dam, Algeria	143	Taamallah et al (2016)
Mexa dam, Algeria	371	Taamallah et al (2016)
Mafragh catchment's outlet, Algeria	1974	Taamallah et al (2016)

Mean sediment yield of 61 t km^2 yr^{-1} has been reported by Meybeck & Moatar (2012) for 86 river catchments of semi-arid and temperate regions, which were daily surveyed for a long term. The Mediterranean river catchments (including Algerian coastal catchments) can be ranked among the most eroded areas, considering this world river catchment value. The sediment yield for Mediterranean rivers, as measured by UNEP/MAP/MED POL (2003) is around 580 t km^2 yr^{-1}, but because of the considerable reservoirs construction, the actual sediment flux is reduced to about 251 t km^2 yr^{-1}. In zit Amba dam the annual rétention of total dissolved solides (TDS) is about 100 000 tons. These values still however low compared to the world river mean (30 t km^2 yr^{-1}), noticed by Meybeck & Moatar (2012). Bouchareb (2013) reported low soil salt losses, ranging from 6-40 t km^2 yr^{-1}. When reaching the Kebir West outlet, soil loss increases to exceptionally high rate reaching 325 t km^2 yr^{-1}. This kind of soil degradation is 2.5 to 11-fold higher than that recorded in the Ebro River' outlet (Négrel et al 2007), for example. The net sediment flux that has attained the catchment outlet, issued from behind dam reached 6 000 tons.

Conclusions. This study highlights the following points:

- the water intercepted and stored in dam has led to a reduction in flow at the exit of dam by 36%;
- the delivered waters from the Zit Amba reservoir have high contents of total dissolved solids. Retention of TDS in the dam is in the order of 100 000 tons (50%);
- it is considered that the water of the basin studied, is on the other hand, and has a low content in TSS, particularly at the mouth of the river. The retention rate of TSS is 67% of the receiving sediment masses.

References

Aminot A., Chaussepied M., 1983 Manuel des analyses chimiques en milieu marin. CNEXO, Brest, 395 pp.

Aubert G., 1976 Les sols sodiques en Afrique du Nord. Annales de l'Institut National Agronomique-El Harrach 7(1):185-196.

Avilés A., Niell F. X., 2007 The control of a small dam in nutrient inputs to a hypertrophic estuary in a Mediterranean climate. Water, Air and Soil Pollution 180:97-108.

Belhadj M. Z., Boudoukha A., Mezedjri L., 2011 Qualité des eaux de surface et leur impact sur l'environnement dans La wilaya e Skikda (Nord-Est de l'Algérie) (Contamination naturelle par le Mercure). European Journal of Scientific Research 56(2):204-211.

Benblidia M., 2011 L'efficacité d'utilisation de l'eau et approche économique. Etude nationale, Algérie, CAR/PNUE/PAM, Plan Bleu, Sophia Antipolis, 24 pp.

Bouchareb N., 2013 Transferts et géochimie de l'azote, du phosphore et du silicium des bassins des oueds Kebir-Rhumel, Kebir ouest et Saf-saf au littoral. PhD thesis, Univertsity of Annaba, Algeria, 111 pp.

Chen C. T. A., 2000 The Three Gorges Dam: reducing the upwelling and thus productivity in the East China Sea. Geophysical Research Letters 27:381-383.

De Luis M., Raventós J., González-Hidalgo J. C., Sánchez J. R, Cortina J., 2000 Spatial analysis of rainfall trends in the region of Valencia (East Spain). International Journal of Climatology 20(12):1451-1469.

Dürr H. H., Meybeck M., Hartmann J., Laruelle G. G., Roubeix V., 2011 Global spatial distribution of natural riverine silica inputs to the coastal zone. Biogeosciences 8: 597-620.

Favis-Mortlock D. T., Savabi M. R., 1996 Shifts in rates and spatial distributions of soil erosion and deposition under climate change. In: Advances in hillslope processes. Anderson M. G., Brooks S. M. (eds), Wiley, Chichester, pp. 529-560.

Favis-Mortlock D. T., Guerra A. J. T., 1999 The implications of general circulation model estimates of rainfall for future erosion: a case study from Brazil. Catena 37:329-354.

Fox H. R., Moore H. M., Newell Price J. P., El Kasri M., 1997 Soil erosion and reservoir sedimentation in the high Atlas Mountains, Southern Morocco. IAHS Publications-Series of Proceedings and Reports 245:233-240.

Friedl G., Teodoru C., Wehrli B., 2004 Is the Iron Gate I reservoir on the Danube River a sink for dissolved silica? Biogeochemistry 68:21-32.

Gray J. R., Glysson G. D., Turcios L. M., Schwarz G. E., 2000 Comparability of suspended-sediment concentration and total suspended solids data. U.S. Geological Survey, Water-Resources Investigations Report 00-4191, Reston, Virginia, 20 pp.

Harrat N., Achour S., 2011 Qualite et reactivite des eaux des barrage de Zit El-Emba alimentant la station de traitement d'Azzaba. Courier du Savoir 11:113-117.

Hart B. T., Bailey P., Edwards R., Hortle K., James K., McMahon A., Meredith C., Swaling K., 1991 A review of the salt sensitivity of the Australian freshwater biota. Hydrobiologia 210:105-144.

Lehner B., Reidy Liermann C., Revenga C., Vorosmarty C., Fekete B., Crouzet P., Doll P., Endejan M., Frenken K., Magome J., Nilsson C., Robertson J. C., Rodel R., Sindorf N., Wisser D., 2011 Global reservoir and dam database, Version 1 (GRanDv1): Reservoirs, Revision01, Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). Available at : http://dx.doi.org/10.7927/H4HH6H08. Accessed: March, 2017.

Ludwig W., Dumont E., Meybeck M., Heussner S., 2009 River discharges of water and nutrients to the Mediterranean and Black Sea: major drivers for ecosystem changes during past and future decades. Progress in Oceanography 80:199-217.

Meybeck M., Ragu A., 1996 GEMS/water contribution to the global register of river inputs. GEMS/Water Programme (UNEP/WHO/UNESCO), World Health Organization, Geneva, Switzerland.

Meybeck M., Moatar F., 2012 Daily variability of river concentrations and fluxes: indicators based on the segmentation of the rating curve. Hydrological Processes 26(8):1188-1207.

Meybeck M., Friedrich G., Thomas R., Chapman D., 1992 Rivers. In: Water quality assessments: a guide to the use of biota, sediments and water in environmental monitoring. Chapman D. (ed), Chapman & Hall, London, pp. 238-316.

Milliman J. D., 1997 Blessed dams or damned dams? Nature 386:325-327.

Milliman J. D., Farnsworth K. L., 2011 Runoff, erosion, and delivery to the coastal ocean. In: River discharge to the coastal ocean: a global synthesis. Cambridge University Press, Cambridge, UK, pp. 13-69.

Nearing M. A., 2001 Potential changes in rainfall erosivity in the U.S. with climate change during the 21st century. Journal of Soil and Water Conservation 56(3):229-232.

Nearing M. A., Jetten V., Baffaut C., Cerdan O., Couturier A., Hernandeza M., Le Bissonnais Y., Nichols M. H., Nunes J. P., Renschler C. S., Souchére V., van-Oost K., 2005 Modeling response of soil erosion and runoff to changes in precipitation and cover. Catena 61(2):131-154.

Négrel P., Roy S., Petelet-Giraud E., Millot R., Brenot A., 2007 Long-term fluxes of dissolved and suspended matter in the Ebro River Basin (Spain). Journal of Hydrology 342(3-4):249-260.

Nunes J. P., Seixas J., 2003 Impacts of extreme rainfall events on hydrological soil erosion patterns: application to a Mediterranean watershed. World Resource Review 15(3):336-351.

Ounissi M., Bouchareb N., 2013 Nutrient distribution and fluxes from three Mediterranean coastal rivers (NE Algeria) under large damming. Comptes Rendus Geoscience 345:81-92.

Parry R., 1998 Agricultural phosphorus and water quality: a US Environmental Protection Agency perspective. Journal of Environmental Quality 27(2):258-261.

Petts G. E., 1984 Impounded rivers: perspectives for ecological management. John Wiley & Sons, Chichester, UK, pp. 11-18.

PNUE/P.b., 2003 Les menaces sur les sols dans les pays méditerranéens. Sophia Antipolis, Plan Bleu, ISBN, 2-912081-13-0, 70 pp.

Pont D., Simonnet J. P., Walter A. V., 2002 Medium-term changes in suspended sediment delivery to the ocean: consequences of catchment heterogeneity and river management (Rhône River, France). Estuarine, Coastal and Shelf Science 54(1):1-18.

Preston S. D., Bierman J. R. V. J., Silliman S. E., 1989 An evaluation of methods for the estimation of tributary mass loads. Water Resources Research 25(6):1379-1389.

Probst J. L., 1992 Géochimie et hydrochimie de l'érosion continentale. Mécanismes, bilan global actuel et fluctuations au cours des 500 derniers millions d'années. Sciences Géologiques Mémoires 94, 167 pp.

Pruski F. F., Nearing M. A., 2002 Climate-induced changes in erosion during the 21st century for eight U.S. locations. Water Resources Research 38(12):1-11.

Remini B., 2010 La problématique de l'eau en Algerie du Nord. Larhyss Journal 8:27-46.

Serrat P., Ludwig W., Navarro B., Blazi J. L., 2001 Variabilité spatio-temporelle des flux de matières en suspension d'un fleuve côtier méditerranéen: la Têt (France). Comptes Rendus de l'Académie des Sciences 333(7):389-397.

Taamallah F. Z., Laskri H., Amira A. B., 2016 Transport and retention of dissolved and suspended solids across the Mafragh catchment (Algeria). Advances in Environmental Biology 10(5):177-185.

Teodoru C., Dimopoulos A., Wehrli B., 2006 Biogenic silica accumulation in the sediments of Iron Gate I reservoir on the Danube River. Aquatic Sciences 68:469-481.

Touaibia B., 2010 Problématique de l'érosion et du transport solide en Algérie septentrionale. Sécheresse 21(4):333-335.

Ulbricha U., Lionello P., Belusic D., Jacobeitd J., Knippertze P., Kuglitschf F. G., Leckebuschg G. C., Luterbacherh J., Maugerii M., Maherasj P., Nissena K. M., Pavank V., Pintol J. G., Saaronim H., Seubertd S., Toretih A., Xoplakif E., Ziv B., 2012 The climate of the mediterranean region: from the past to the future. Elsevier, Oxford, pp. 301-346.

UNEP/MAP/MED POL, 2003 Riverine transport of water, sediments and pollutants to the Mediterranean Sea. MAP Technical Reports Series No. 141, UNEP/MAP, Athens, pp. 1-118.

Vörösmarty C. J., Meybeck M., Fekete B., Sharma K., Green P., Syvitski J. P. M., 2003 Anthropogenic sediment retention: major global impact from registered river impoundments. Global and Planetary Change 39(1-2):169-190.

Walling D. E., 2006 Human impact on land-ocean sediment transfer by the world's rivers. Geomorphology 79(3-4):192-216.

Williams J. R., Nearing M. A., Nicks A., Skidmore E., Valentine C., King K., Savabi R., 1996 Using soil erosion models for global change studies. Journal of Soil and Water Conservation 51(5):381-385.

Zhang S. R., Lu X. X., Higgitt D. L., Chen C. T. A., Sun H. G., Han J. T., 2007 Water chemistry of the Zhujiang (Pearl River): natural processes and anthropogenic influences. Journal of Geophysical Research: Earth Surface (2003–2012) 112(F1).

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