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Erosion and industrial pollution of Seman River

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Introduction

Albania has a rich hydrographic system. The rivers Drin, Bune, Mat, Ishëm, Erzen, Shkumbin, Vjosa, and their branches constitute the hydrographic network of large rivers flowing from average height of 703m above the sea level towards the Adriatic Sea. Seman River is one of the biggest of the country, with a length of 281km and a watershed area of 5649km2, formed by the conjuction of the river Devoll and Osum River.

The river basine and its watershed are characterized by high rates of soil erosion and river banks sediments, estimated at an average of 1.2 million tons/ year, due to the peculiarities of the watershed basin in the mountain, more than 2/3 of the total length of the river, and to the lowland area at the junction point between Osumi River and Devoll (at Kozare area), to its river delta and to its morphological characteristics and soil texture with high content of sand and silt. The river and surrounding lands are exposed to pollution from activities conducted by the industry of extraction and processing of oil in Kuçova, Berat, Patos-Marinez and from oil discharges at river Gjanica, coming from the oil processing in Ballsh factory and from the wells and oil extraction along this segment.

This article aims to address precisely two issues: a) the high level of erosion and b) industrial pollution from oil, which are sensitive phenomena, compared with other rivers, as well as to analyze the causes and impacts that impact environmental, social and economic development in the urbanized area along the river basine. Seman River has undergone significant morphological changes on his river delta along a coastline of 32 km, causing coastal erosion and frequent changes to the river delta. Based on the existing situation and environmental analysis, protective measures will be proposed on these territories in order to respond to the rehabilitation of the degraded and polluted areas and improve responsibilities of research institutions.

Main theories

This study is based on the assessment of This study is based on the assessment of the level of erosion and pollution of Seman River, as these indicators in this case are more relevant compared to other rivers in Albania, by analyzing the morphology and geology of river, human interventions, causes and effects of erosion and environmental pollution.

For this purpose field surveys and terreain measurements were undertaken. There were also done a series of analysis regarding chemical groundwater, river morphological changes, the exploitation of river basin, and the assessment of potential flood hazards on residential areas, by evaluating the level of implementation of protection and rehabilitation measures.

According to the theory of river basin management, in order to reduce the erosion and pollution of the river, the priority is given to the study of gravel reserves and their exploitation based on predetermined criteria, the gradual replacement of river gravel with materials from other sources, the increase of vegetation cover in the basin, the reduction of polluting substances, particularly hydrocarbons

that are discharged into the river and in the drainage basin from the wells in the oil fields to the Gjanica River.

Methodology of study

The methodology of the study focuses on the assessment of the level of erosion and pollution of the Seman River including the surrounding areas, cosidering the continuity with Devoll and Osum branches, which flow into the larger body of Seman River in its last 90 km to the sea.

The existing context analysis are based on the following field measurements and surveys: soil loss calculation related to the erosion, the monitoring of water quality, physical and chemical indicators of the soil, causes and sources of river chemical contamination from oil resource management, problems related to practices of bad exploitation of gravel, as well as alternatives of protection against erosion and pollution.

Geomorphological characteristics of the Seman Basin

The Seman River is formed by the conjunction of Devoll and Osum branches. It has a length of 281 km and is situated at 863m above the sea level. The slope of the river bed is 3.6% and is considered mainly as a mountainous river till the point of conjuction with two branches.

The geomorphology of the Seman river bed is simpler compared to other rivers in Albania. As for the morphological configuration, the river bed is divided into two parts: from the conjunction of Devoll with Osumi River in Kozare (west of Kucova) to the village of Seman, the river has meandering features. From the conjuction point of Devoll with Osum until the rivermouth, all over its length the river has a plain character. On both sides of the river bed is formed an alluvial field, made of sandy, clay and silt. In the second segment, the geomorphology of delta and other environments is composed of sedimentation with sand deposits and sand dunes, lagoon deposits, beach and maritime deposits. As a result of sand dunes along the shore, the river has often changed its bed. The organic sediments of the lagoon, along the river bed, continue to develop marsh processes.

Devolli and Osumi at the junction point with the Seman River in Kozare, directly affect its morphological features, at the level of erosion and pollution of the Seman River. In the upper stream of the Devoll River, the torrents that constitute it, carry loamy materials such as clay, sand, conglomerates and coal-containing particles.

From the gorge of Zemblak to Maliq, the river bed passes through the marsh deposits, further meets the ultrabasic formations, and in the Gramsh valley passes over unsteady flysch structures with a powerful erosive activity.

In the Devolli mountain chains, the valley takes on the shape of a canyon, with very steep slopes, further distinguishing the erosive-accumulative terraces. In the lower stream of Devoll, from the mouth of Tomorricë to Kozarë, in 35 km of length, considering the genesis and geomorphology, we can distinguish tectonic-erosion valleys, developed river basins on several levels, of an erosive-accumulative character.

The Osumi watercourse starts from the Kolonja Mountains to the Gorge of Mican, forming a 24 km long valley with erosive-accumulating terraces. Up to Çorovoda, the river bed is placed on karst, flysch and ultra-basics deposits. The deep erosion of the valley is currently very intense due to the influence of tectonic movement of the region, the steep slope and the low vegetation coverage. From Çorovoda till the junction point with Devolli branch, the river flows through flysch, alluviums and limestone formations.

In the slopes of valley the erosion is very intense. From Poliçani, there are up to 5 levels of terraces, which indicate that the river is in the phase of full maturity. In the lower course of Osumi river: from Berat, at the junction point with Devoll branch, the river forms many meanders and increasing gravel amounts. In this part the river bed is around 200-300m wide, and is placed on the old river bed, which has formed the surrounding plain. Osumi transports to Seman about 995 million m3 of water per year, an average flow of 32.5 m3/ sec and an annual rate of solid flow of 1.35 million m3.

Geological construction of the Semani basin

The geological construction of the basin is characterized by various layers on the slopes and the type of rocks in which it is composed (Devoll and Osum). In certain segments of the Devoll and Osum River, weak rocks such as clay, flysch, especially in the conditions of very steep terrain, are eroded faster than other materials. The steep terrain, the height of Devoll and Osum River and its geological composition reduce slope stability, provoking the erosion and collapse of rocks.

The Semani River is fed with alluvial materials from Devolli and Osumi branches; its river bed is covered with fine sand along most of its length, which

contains quartz, sand, lime and gypsum particles. The River valleys and the hilly slopes are made by the deposit of alluvial materials deposited at different times and consequently the sustainability of the river banks along the segment changes considerably. The deep river valleys show deep erosion and the steep slopes of the river stimulate erosion, slides and the collapse of the rocks.

The amount of annual rainfall on the Seman river basin ranges from 1,000 to 2,000mm with an intensity of 80% on the period from November to March, an average annual flow rate of 101m3 / sec, a maximum flow 1,800m3 / sec and a maximal flow to 3000m3 /sec (monitoring of 1962). In the case of the Devoll and Osum rivers, the flow of surface water and hydro-meteorological factors such as precipitation, snow, temperature change, plant cover change, and economic activity, urge the intensification of erosion forms of the basin and river banks. A high level of flows erodes the slopes of the valleys and the eroded materials are deposited in the river. The rocky slopes spoil their balance and break down tumbling, sliding and collapsing.

Erosions on the Seman Basin

The Seman river is one of the most erosive rivers of the country. The analysis has shown that from the point of junction of Devoll with Osum to Mbrostar, the water turbulence varies from 3,500 to 5,500gr/ m3. The evaluation of river erosion and the Seman basin helps to plan the measures of land protection and reduce the soil loss from the erosion, floods and river defense engineering facilities. The annual quantity of suspended materials carried in the Seman River and the rivers that form it, is about 7.5 million tons/ year, which indicates the high level of river erosion in the whole watershed. The Semani River is the most turbid river in the country. The suspended solid substances is equal to a surface of 730 ha with a thickness of 1m.

During the last 25 years, several forms and causes of intensification of Seman erosion have been identified, such as coastal erosion and delta changes, unsuitable exploitation of river gravel, slope deforestation and lack of vegetation on the river banks. As a consequence, the river dikes which protect the surrounding lands and settlements from the flood have been damaged in 15km or 25% of their total length. 50% of the penels that protect river banks from the erosion have lost their function. The loss of soil from erosion varies from 3-9 ha per year. In the extreme years, about 30 thousand ha of agricultural land are flooded by the Seman River. The long time exploitation (1991-2012) and the lack of any criteria for the exploitation of the river gravel in the segment from Ura-Vajgurore up to Mbrostar, have caused deep erosion of river banks along the whole segment.

By monitoring the erosion of the banks of the Seman River in a segment of 5 km on both sides of the Mbrostar Bridge, the loss of soil in the depth of the profile is estimated at 241,000 ton / year (Lushaj Sh, Laze P, Kovaci V etc.). Among the main causes of erosion are:

i) The exploitation of the river gravel without any criteria. The soil texture on Seman riverbanks is dominated by sand and lime particles and is associated with the shattering of the river banks. From the study of lands around the Seman River (Lushaj Sh, Zdruli P, Cara K) it results that the soil structure varies according to the areas. On the Osumi banks dominates the soil with sand content of 41.12- 41.72%, silt 31.44-35.64% and clay 23.24-26.84%. In general, in the whole segment of Seman River from the joint point till the rivermouth, dominates the soils with a high content of the sand and silt, and wth high erosion predisposition.

ii) The watershed surface of Devoll and Osum lie in the mountainous and hilly area, while the lowland part begins at the point of juction of Devoll with Osum, up to the river mouth. In this segment, the rain intensity increases with 80%during the period between November and March. The maximum river discharges are recorded in the years 1962-1963 with 3,000m3 / sec. Solid discharge of the Seman River during the winter and spring seasons represent 70% of the annual amount, in spring 20% and 10% in summer. During November and December, flows about 30% of the total solid mass discharge.

iii) The high steep of slopes of Devoll and Osum River stimulate the soil erosion and sediment transportation due to the low vegetation cover of slopes.

iv) Only 30% of the surface of the Seman basin is covered by vegetation, so the intensity of erosion is increased. Under these conditions the soil surface is easily eroded at the highest limits of up to 180 ton/ ha. Therefore, the afforestation of the river banks and that of the watershed in general is one of the most important objectives.

v) Until 2003, rivers have been exploited without any criteria for gravel mining, causing hydrotechnical changes to the river bed, erosion of the river banks and changes in the coastline. The National Water Council Decision No. 1, of

Fig1 / Erosion of Semani River in 2005
source / drawing by Artan Kacani

09.01.2003 introduced some regulations on the way and time of use of gravel mining. This decision prohibited the gravel mining in several segments of the Seman River such as: in front of Marinza, on both sides of Kuci Bridge, etc. On the Osum River, 500m from Ura Vjagurore any kind of uses were prohibited. In 2006, the new decision envisaged the gravel mining only in the period between 1st of June to 31st of October of each year. This decision aimed to limit the harmful practices of gravel mining with consequences on the degradation of the river system, soil loss and erosion of river banks and the increase of flooding areas. However, this decision has not been properly implemented and informal gravel mining has continued during that period.

vi) Only 21% of the surface of the watershed consists of permeable formations, 51% semi-permeable and 28% impermeable. The permeable formations in some segments allow splitting of riverbanks and flooding.

vii) The demage of the engineering protection works (protective penels, dikes in the range of 25-60% in the period 1991-2003) due to high inflows, the damages of the dikes and protection structures of the Seman River, the agricultural lands have been flooded in 14 places situated from the Devoll and Osum junction, to the rivermouth.

viii) Along the river segment there is found massive erosion of agricultural land, especially in the periphery of the junction point between Devoll and Osum River. There are deviations of the riverbad, and mass erosion of agricultural land like in Grecalli, Mbrostar, Ndërnenas, Grykë, Jagodinë, Sukë. Close to the river delta (in the Seman village) in a segment with a length of 6km there is a continuous river bank erosion. The erosion level on the river banks in the segment Murriz-Toshkez varies from 25 to 40 ton/ ha. In the segment from Kuçi bridge up to Mbrostar, the main cause of erosion is the damage of the protective works and the

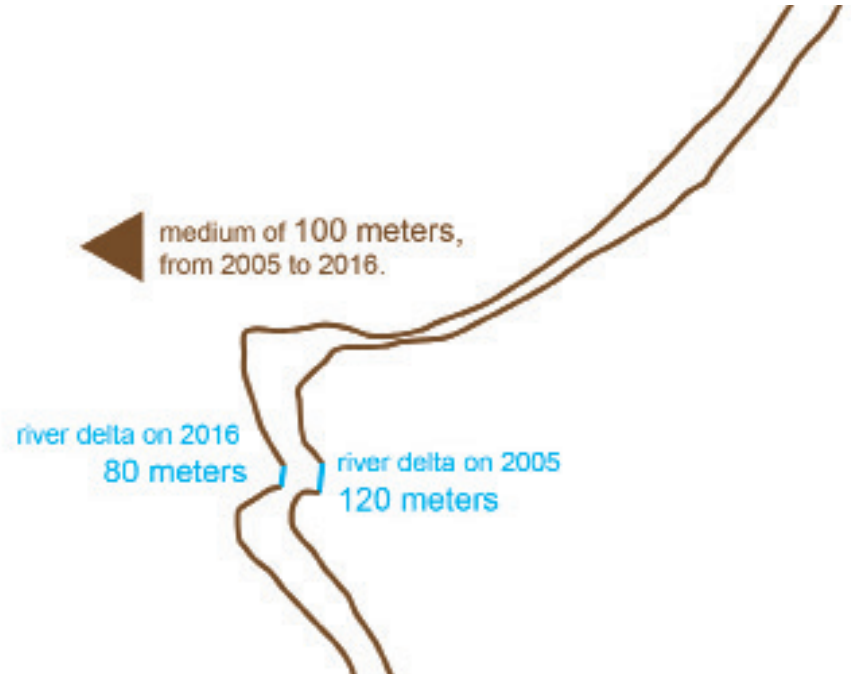

Fig2 / Change of the river mouth
source / drawing by Artan Kacani

gravel mining.

Change of river mouth

The Seman River from 1870-1990 has The Seman River from 1870-1990 has changed its delta 6 times, in average every 18-22 years. In the same period the coast has been eroded along 3-7km. The turbidity changed in 1918, 1924-1925, 1937, 1957, 1978. With the construction of the Karavasta hydropower plant, erosion intensity on the coastline increased from 15 to 35m per year. Seman's beach was build during the years 1958-1962 in an area with distinctive erosion phenomena. Some years after the construction it was further destroyed by coastal erosion and the advancement of the sea to the land. In 1957, the river delta moved 4.6 km to the south. In 1978, the river was divided into two parts 6km south of the 1957 site, located 2 km away from each other, advancing inland. While in 1990, the river mouth compared to 1978, has advanced toward the south. These moves have coused changes in the coastal line as well as have simulate coastal erosion, with sea advancment towards the land in some segments, and land advancement towards the see in other segments.

The After the 1990s there has been a large amount of loss soit due to the intensive use of gravel mining materials and the minimal amount of material transportantion in the river delta, while in the last 5 years, due to interruption of gravel mining explotations, an advancement of the land towards the sea is observed.

Coastal erosions

The implementation of measures for the protection of the coasts from erosion such as the offshore reforestation, engineering measures, strengthening of embankments, abolition of gravel mining utilization will stabilize changes of the coastline in particular changes of the rivermouth.

The pollution of the Seman River and surrounding lands

The Seman River is one of the most polluted rivers in the country. Specific causes of pollution are (i) hydrocarbon discharged by the oil extraction industry in the Patos-Marines area, where about 2,400 wells are used, (ii) leaks from the Ballsh oil processing plant, transported through the Gjanica River and shed in the Seman river (Iii) accidental oil spills during transport and collection of the product, (iv) urban solid wastes, industrial wastes, direct discharged wastewater and unsettled septic tanks that are discharged untreated into the Osum, Devoll and Seman rivers. The water of Osum, Seman and Devoll Riverwas used for irrigation in agriculture, which caused chemical, toxic, hydrocarbon deposits and environmental and human health hazards. Another source was the battery production plant (built around the 1970s in Berat Uznove) which discharged a toxic metal that causes soil contamination around the plant area, Osumi river pollution and caused life and health hazards for the population of the area.

From the monitoring of 6 water samples in the Osum and Devoll River (Bihuri M, Lushaj Sh, 2015) (analyzed by DFS) results that the Zagori brook discharge to the Osum River waste water lead (Pb) from

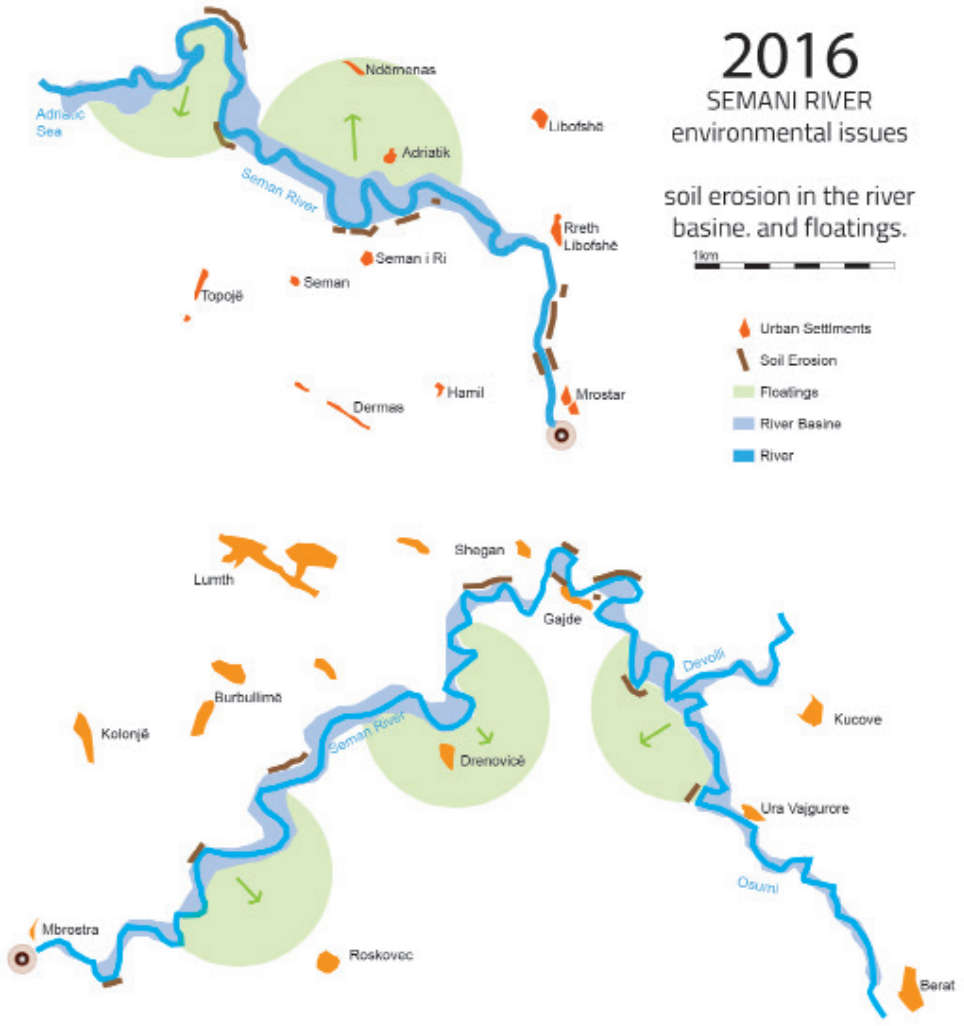

Fig3 / Erosion of Semani River in 2016
source / drawing by Artan Kacani

the former production plant of batteries, which has been operating until 2008, as well as the untreated industrial waste of various industries in Berat. In the oil field and the battery production plant, in the Uznova and Ura-Vajgurore area, the number of people affected by chronic diseases (allergies, allergies, epilepsy to children, behavioral changes, blood diseases, leukemia, etc.) was higher compared to other areas. The oil wells distributed around the residential areas in Kuçovë and the oil deposits close to the Osumi River, in the Patos-Marinez oil depot area (map 2) polluted the agricultural lands, which have lost their functions as well as underground and surface water, degradation of the ecosystem soil and aquatic flora. Devolli and Osumi water flux ranges from 8-8.2, electrical conductivity (ECW) 375-425 μs / cm, solid suspended matter 179-650 gr / l, NKO 7.6-9.75 mg / l, NBO 4-6 Mg / l (DSHP, 2014), addition of suspending agents, ammonia, sulfates, phosphates, nitrates, Cr, and dissolved oxygen digestion. This situation indicates that the water of the rivers is polluted and with high content of loamy materials.

From the oil processing plant in Ballsh and Patos-Marinza, the residues of hydrocarbons with high content of toxic substances are discharged to the Gjanica River and then flowed to the Seman River, with direct impacts on river fauna and the quality of groundwater. According to the calculations (based on the level of inflows and concentration of water contaminants) it results that the Gjanica River transports more than 10 thousand m3 of liquid waste (hydrocarbons and industrial), causing deterioration of the biodiversity and water quality, and soil damage. Monitoring on agricultural lands in the Kuçovë-Patos-Marinza oil field and around Ballsh oil processing plant, in the depth of 0-30cm, shows that the content of Ni, Pb, Cr, Vn (vanadium) and hydrocarbons as contaminant Oil extraction activity have a high concentration.

This data shows that the content of Ni, Vn and hydrocarbons in the soil is high, compared to the allowed levels of Ni, Pb, Cr, hydrocarbons. In other sampling places, land analysis shows a high content of heavy metals. In the Marinza lands close to the oil wells, Nickel content is (Ni)

630 ppm and lead pb) 359 ppm. While in Ura Vajgurore, close to the oil well area, the Ni content ranges from 360-410 ppm and lead (pb) 347-365 ppm. The outbreak of hydrocarbons has contributed to the general damage of the living world or the removal to other aquatic environments. Seman River water was used for irrigation of agricultural lands and the amount of hydrocarbons in the soil has increased. The three-point systematic analysis (Vajgurore Bridge, Kuc's Bridge and Mbrostar Bridge) shows the Seman River pollution from the over allowed limits of hydrocarbons, to the damage of water biodiversity.

Possible rehabilitation measures

The watershed, the banks and especially the lands in the lowland area of Seman River across the entire length of the segment from Kozara to Mbrostar and close to the river mouth are subject to a powerful erosive action. In order to limit erosion and landslides on the banks of the river, it is necessary to plan and implement some measures such as:

- To implement a basin management and restoration program, addressing clear responsibilities: actors, projects, staff, expectations, engineering protection measures, damage restoration, reconstruction, protective infrastructure and land use planning, defense and management at of watershed;
- River management and rehabilitation is a fast growing topic for environment, geology and ecology scientists (Gary J, kirstiea A. Fryirs).
- To determine, referring to the environmental permit for the use of river gravel mining by the subjects, the area of exploitation on the basis of reserves, the application of exploitation criteria, so that exploitation does not deteriorate the river's dynamic and hydrologic parameters. The exploitation is based on the geological, morphological, hydrological, land protection, hydro technical works of engineering facilities and the environment. The volume of use of gravel mining must be calculated by preserving the balance between the used quantities with the quantity transported to the river mouth, with the aim of reducing coastal erosion.

On the last 25 years, due to the break of these balances, coastal erosion has been intensified in different directions. Currently the level of the gravel mining used in the Seman River should be reduced to increase the flow rates of accumulation, in order to reduce the impact on the morphology of the canal and coastal erosion.

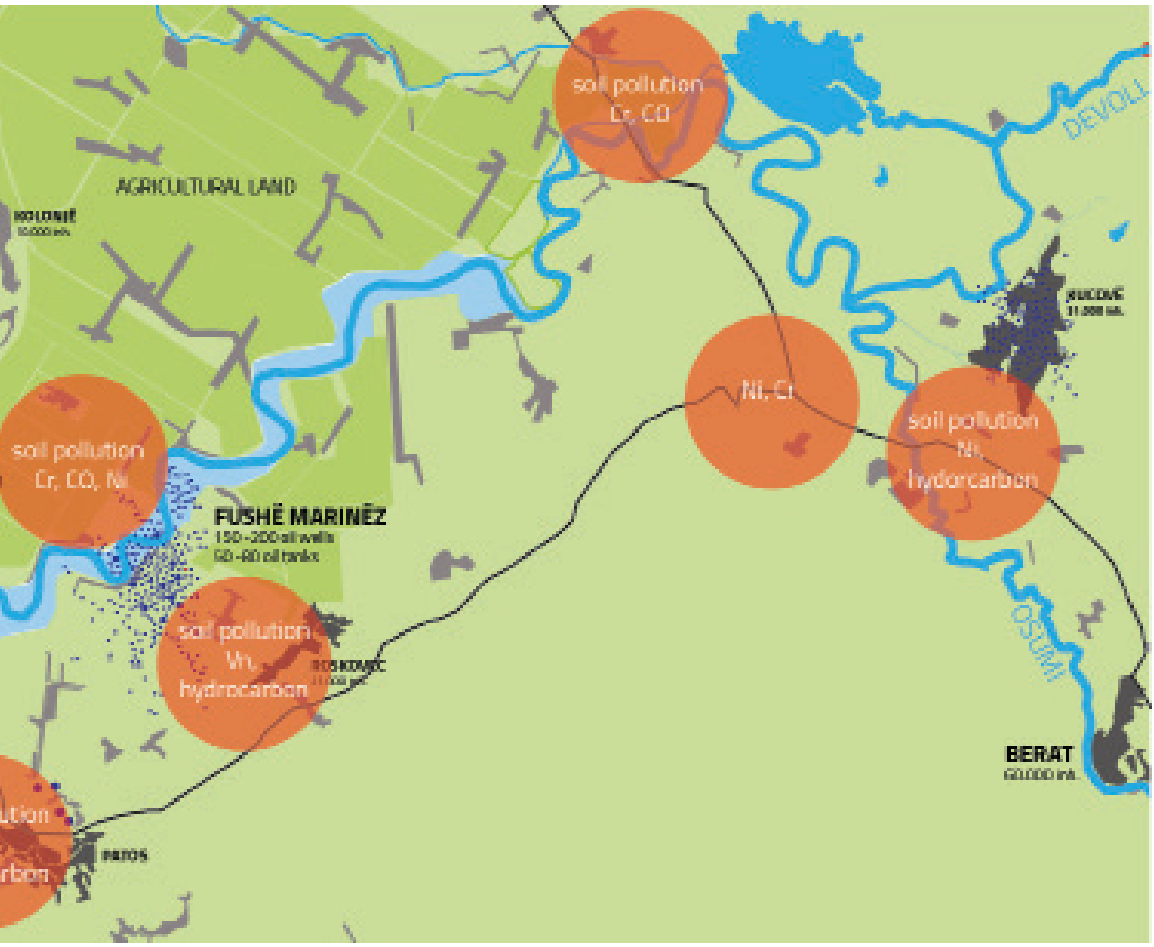

Fig4 / Soil pollution map
source / drawing by Artan Kacani

No.	Sampling place	Ph	Ni ppm	Pb ppm	Vanadium(Vn) ppm	Hydrocarbure mg/100 gr toke	Cr ppm
1	Marinez-Patos	7.2	250	114	92.1	246.7	
	Marinez-Patos	8.7	216	114	48.6	129.4	
	Marinez-Patos	8.5	284	126	109	454	
	Marinez-Patos	8.1	216	137	83	117	
2	Kucove	8.7	361	80	101.3		
3	Uzina perpunimit naftes Ballsh		550	370			419
4	Uzina perpunimit naftes Ballsh		581	390			466

Table 1 / Content of heavy metals and hydrocarbons in the land close to the oil field
source / the author

- The method of using the river gravel mining must take into account the erosive effects according to the particulars segments that can change the geomorphology of the canal as soon as the exploitation starts (Kondolf, 1993,5. 1994). Materials should be used only during low flow periods, abandoning the practice of exploitation in the high flow period, prohibiting exploitation under the water level, eliminating the exploitation of river banks. Exploitation should be based on the study of gravel mining reserves by reducing the environmental impacts (prevention, restoration of damages).
- It is necessary to improve the criteria for using gravel mining materials based on projects, estimated reserves, prohibition of exploitation in some problematic and potentially erosive, the rehabilitation of the area after the exploitation, the monitoriation of the existing situation and landscape protection measures. The exploitation project is accompanied by

all the documentation ensuring project utilization and process monitoring (maps, geological conditions, hydro-technical, hydrological data (seasonal flows, condition, potential reserves, area, surface area, manner of exploitation, protection and rehabilitation of protective works, protection of land from erosion, and shore rivers. To apply hydrological criteria, which means that no project is drafted or licensed in case there is no hydrotechnical study (of the river and river channel regime, river protection works, conditions of the banks and the river configuration). River conservation and management cited by (Philip J & Paul J Raven), essentially includes the improvement of legislation, policies, institutional responsibilities,

- Good practices and public participation.
- Construction of defensive structures (panels, 20 km of dike, river basin forestation in 30-50% of the river segment, repair of damaged panels, construction of 8 protective panels on the shores of the river from the Mbrostari Bridge to the river mouth and reforestation and improvement of forest coverings along the banks River about 9-12ha from the Mbrostari Bridge at the river mouth.
- The pollution of the river and surrounding land is a problem, which asks for a solution, by improving the technology of exploitation of wells, the elimination of accidental spills and transfer of deposits from agricultural land, uncontrolled explosions, the change in the structure of agricultural production in the contaminated areas to avoid risks for food safety and rehabilitation of contaminated land.
- The prohibition to spill hydrocarbon in Seman from the Gjanica River requires a special study.
- The establish and put to work the water monitoring network for the suspended material, the floods, soil and water pollution of Semani and Gjanica, in all periods of the year.
- To stop using rivers gravel mining, replacing them with quarrying gravel mining materials. . After monitoring the reserves, to use only those segments in which the senders that cause flooding are collected, in order to avoid the impact on the morphology of the river channel, the change of the costal line and the alteration of the river mouth.

Conclusions and recommendations

The Seman river compared to other rivers in the country, has the highest level of erosion, not only from the point of junction of Devoll with Osum, but also on the Devoll and Osum branches. The amount of loamy material in the river flow varies from about 7.5 million tonnes per year, which indicates the high erosion rate, the erosion of the shores, and the high damage of the engineering structures. In extreme years the flow rate reaches 3,000 m3 / ha. The shores of the Seman River are subject to a strong erosive action throughout its length, and on the shores and agricultural lands, especially in the flat area across the entire length of the Seman River (Kozare-Mbrostar-grykederdhje). The geological construction, the high slopes along the Devoll and Osum flow, the sland structure with high sand content of the soil, the lack of vegetation cover on the banks of the river and the watershed, and the limited use of gravel mininges for 25 years of construction, costitute the main cause of disruption of the hydrotechnical balance of the river, the frequent alteration of the estuary, and the massive erosion along the river banks to the surface and in depth. The Seman River is polluted also by agricultural activities such as fertilizers, pesticides, urban waste etc, but the main pollution,which needs attention is related to hydrocarbons, as the Kuçovë-Patos-Marinza plain area is an oil field that is exploited through wells, where about 30,000ha of land is polluted. In addition, the Gjanica River collects the flow of the Ballsh oil processing plant, as well as the wells flow, pouring them into the Seman River. The dumping of hydrocarbons on land and river has increased the content of heavy metals and hydrocarbons, damaging heavy water biodiversity, water quality, soil pollution by the use of irrigation water and the quality of life of the inhabitants.

Recomandations

I) The management plan of the seashell watershed needs to be developed, in order to: identify problems and opportunities; start the planning and implementation of the technical, engineering, defense and rehabilitation measures of the river basin, foreseeing the rehabilitation of defensive structures (embankments, river basins); plan the afforestation of uncovered riverbank sections (new afforestation and vegetation densification), the river channel and river banks, in order to reduce the risk of erosion, anti-erosion measures; decide on a criterion-based and limited use of river gravel mining, based on the study of reserves.

(II) Foreign and domestic oil and gas companies in the Patos-Marinza and Kuçova areas must submit a plan for the rehabilitation of damages caused to the oil field for soil, water, environment and soil pollution, and health of the population as part of the environmental use permit.

Fig / Sedimentation in the Semani River Delta
source / Vezir Muharremaj

(III) The responsible state institutions, in cooperation with the exploiting companies, should carry out studies on the treatment of the contaminated water of Gjanica River, which discharges hydrocarbons in Seman river, starting from the source that is created in the oil processing plant in Ballshit factory and in continuity.
(IV) Integration of territorial planning, defense and management at the watershed level, so that the economy, the environment and the protection of the territory can act all in one.

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