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Preliminary analysis of sediments pollution of the coastal sector between Crotone and Strongoli (Calabria - southern Italy)

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ABSTRACT

This work studies the pollution of the beach sediments along the coastal sector between Crotone and Strongoli towns. 24 samples were investigated through grain size and chemical analyses. The samples are enriched in heavy metals as Ti, Fe, Ni, Co, Ce and V probably related to iron and magnesium minerals. Some samples are characterized by values of As, V, Co and Cr higher than the Italian low limits provided by D. Lgs. 152/2006.

These anomalies can be ascribed to a combination of natural causes and anthropogenic activities.

KEY WORDS: Crotone and Strongoli; sediments pollution; environment monitoring.

INTRODUCTION

The coastal area between Crotone town and Strongoli village is characterized by many pollution sources as industrial areas, among which the abandoned Pertusola metallurgic factory and the active Strongoli Biomass Central, and widespread asbestos cement roofings.

During the last decades, the public opinion has drawn its attention on this area as the World Health Organization recorded in Crotone an average increase in the incidence of carcinoma. In 2011, the Strategic Program of Health and Environmental Ministry of Italy carried out an epidemiological study in this area, including the city of Crotone inside the list of 57 sites of national interest (SIN), as settlements exposed to risk of pollution and to be decontaminated.

Our study is focused on the pollution monitoring of the coastal sediments sampled along the beach between Crotone and Strongoli towns. This work is included within the Project PON "AMICUS" focused on the analysis of asbestos cement (Cannata, 2015), marine intrusion (Vespasiano et al., 2015) and waste disposal aboard ship.

GEOMORPHOLOGICAL AND GEOLOGICAL SETTING

The studied area is located within the physiographic unit included between the Crati and Esaro Rivers mouths (Fig. 1). In the offshore area, the northern and southern boundaries are represented by the Neto-Lipuda and Esaro submarine canyons, respectively (Rebesco et al., 2009). The physiographic unit is characterized by a low and mainly sandy coast landward confined by the Marinella dunal sands (ISPRA, 2012). In the physiographic unit, the main waves' directions are: North (5N), South-Southeast (180N) and Northwest (60N) (APAT, 2003).

The feeding systems of the interested coastal areas are represented by the catchment areas of the Neto River (1073 km^2), Esaro River (110.8 km^2), Talesi Stream (18.5 km^2), Lagonetto Channel (7.8 km^2), Fallao Stream (22 km^2), Ponticelli Stream (18 km^2) and Passovecchio Trench (79 km^2). In the Neto River, which represents the main feeding system of the area crops out: igneous and metamorphic rocks of the Sila Units (Messina et al., 1994), locally covered by thick weathering profiles (Le Pera et al., 2001); the upper Miocene siliciclastic and evaporitic deposits of the Crotone Basin (Barone et al., 2008) and a Plio-Quaternary succession made up by sandy, clayey and marly sediments (Zecchin et al., 2012). The other main drainage area is the Esaro River involving only the Plio-Quaternary deposits.

In the analyzed coastal area, the sands have a manly quartz-feldspar composition with local presence of heavy minerals (zircon, garnet, horneblende and opaque minerals) (Le Pera et al., 2001; Bernasconi et al., 2002).

METHODS

The sampling was carried out during the springtime (May 2015) in correspondence of 5 coastal sectors (KR1, KR2, KR3, KR4, KR5, KR6) located between Crotone and Strongoli (Fig. 2). For each sector, the different morphological elements of the beach were sampled (e.g. swash, berms and dune), in order to collect all representative grain sizes and textural features of the sediments. On each sample grain size and compositional analysis of the main inorganic components were performed. Major and trace elements were determined by using respectively X-Ray Fluorescence (XRF - X Bruker S8 TIGER) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS - ELAN DRC Perkin Elmer SCIEX).

RESULTS AND DISCUSSION

The samples are mainly made up by gravelly sands (18 samples), fine sands (KR 6 and KR 5-5) and sandy gravel (KR 5-1). The chemical composition (Fig. 3a) of the samples is characterized mainly by SiO2 (average value of ~73%), Al2O3 (~10%), followed by CaO, Fe2O3, K2O and Na2O.

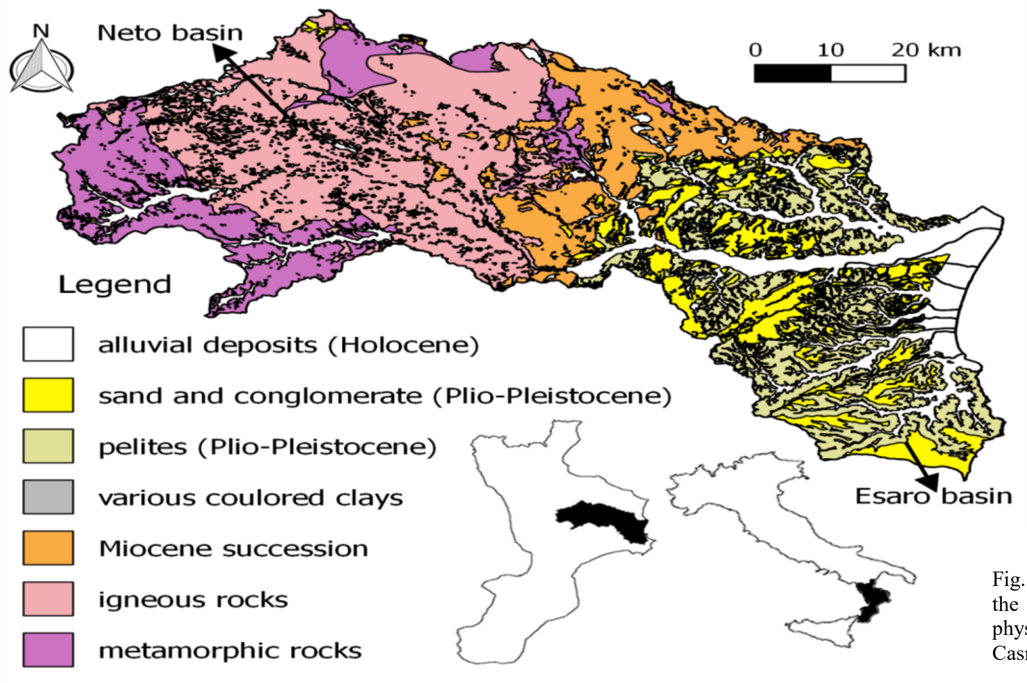

Fig. 1 – Simplified lithological map of the drainage basins that feed the physiographic unit (modified from Casmez, 1967-1969).

High Ba, Ti and Mn concentrations are observed in the section KR 1 with the highest values in KR 1-5 sample (dune). High concentrations in B are present in KR1-3 (2nd berm) and KR 1-5. Secondary peaks in Sr and Rb are recorded in all samples while a peak in Zn is observed in KR 1-5 sample. KR 1-2 (1st berm) is characterized by high Cu value. In KR 2 and KR 3 sections, high Ba (KR 2-3 2nd berm; KR 3-2 between 1st and 2nd berm; KR 3-1 swash), Ti (KR 2-2 1st berm; KR 3-4 dune) and B (KR 2-2; KR 3-2; KR 3-4) are observed. Minor peaks in Mn, Zn, Sr and Rb are present in KR 3 section in all the analyzed samples.

In KR 4, high peaks in Ti (KR 4-3 dune; KR 4-2 2nd berm; KR 4-1 swash), Ba (all samples), B (KR 4-2) Mn, Zn, Sr and Rb in the sample KR 4-1 are recorded.

KR 5 section showed high Ti value in samples KR 5-2 (between 1st and 2nd berm), KR 5-3 (between 2nd berm and dune), KR 5-4 (dune) and KR 5-1 (berm). Secondary peaks in B, Ba and Mn are present in KR 5- and KR5-2 samples. In the last section (KR 6), high Ti concentration are present in KR 6-3 (sampled in correspondence of a dark coloured level) as well as high Mn content in KR 6-2 (landward section of the beach). Minor peaks in B, Sr and Ba are observed in all KR 6 samples.

Fig. 2 – Location of the sampled coastal sectors

On the whole, the chemical composition of the analyzed samples suggests the presence of k-feldspar and plagioclase minerals in the rocks of the source area. Ba and Sr are considered as vicariant elements of K and Ca, respectively, in these minerals.

Furthermore, chemical composition is compatible with the quartz-feldspatic petrographic composition of the sands beach of the study area, as suggested by Le Pera et al. (2001). Major and trace elements concentrations, obtained by XRF and ICP-MS, were compared with the

limit values do not be exceeded in the soil according to the Italian law D. Lgs. 152/2006 (Fig. 3b). The latter discriminates between two environments: urban green public and private spaces (A limit value) and commercial and industrial areas (B limit value).

As values exceed the A limit value (20 ppm) for samples KR 6-1, KR 6-2 and KR 6-3; KR 6-1 and KR 6-3 overtake also the B limit (50 ppm). Co and Cr concentrations are higher than the A limit value (20 ppm and 150 ppm respectively) only in the sample KR 5-5 (representative of a dark coloured layer). Sn A limit value (1ppm) is exceeded in KR 1-1, KR1-4, KR 2-1, KR 3-2, KR 3-4, KR 4-1 and KR 5-2 samples. V displays concentration higher than A limit (90 ppm) in sample KR 6-3 and higher than B (250 ppm) limit in KR 5-5 sample. Optical microscopy performed on this sample (corresponding to the dark coloured layer) revealed, in order of decreasing abundance, the presence of: quartz and feldspar single grains, low grade metamorphic rock fragments, opaque minerals, biotite, epidote, amphiboles and pyroxenes. The roundness of all grains suggests that this dark layer (northward of Neto mouth) could be considered a natural placer. The other elements (Zn, Cu, Pb, Ni, Be, Se, Cd and Sb) considered in the D. Lgs. 152/2006, all show values lower than both A and B limits.

(a)

Sample	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)
KR1-1	81.49	0.10	10.03	1.17	0.02	0.66	2.30	2.23	3.21	0.07
KR1-2	80.93	0.10	9.83	1.12	0.02	0.54	2.23	2.20	3.23	0.07
KR1-3	81.34	0.10	10.08	1.15	0.02	0.54	2.23	2.12	3.33	0.07
KR1-4	79.79	0.11	9.94	1.27	0.02	0.60	2.51	2.07	3.11	0.07
KR1-5	79.85	0.13	9.97	1.57	0.03	0.64	2.79	2.01	2.93	0.07
KR2-1	78.63	0.10	9.83	1.25	0.02	0.57	2.93	2.11	3.30	0.07
KR2-2	80.84	0.12	9.53	1.39	0.02	0.58	2.86	2.03	2.87	0.07
KR2-3	80.22	0.09	9.77	1.06	0.02	0.45	2.22	2.05	3.36	0.06
KR2-4	80.33	0.10	9.85	1.23	0.02	0.54	2.68	2.00	3.21	0.07
KR3-1	79.15	0.10	10.04	1.17	0.02	0.56	2.48	2.27	3.49	0.06
KR3-2	80.21	0.09	10.14	1.09	0.02	0.53	2.57	2.14	3.54	0.06
KR3-3	78.57	0.11	9.69	1.30	0.02	0.56	3.00	1.97	3.20	0.06
KR3-4	78.99	0.12	10.16	1.39	0.02	0.59	2.82	2.04	3.32	0.07
KR4-1	77.95	0.13	11.54	1.27	0.02	0.75	1.88	2.46	3.91	0.07
KR4-2	78.33	0.18	11.10	1.68	0.03	0.86	2.23	2.16	3.49	0.08
KR4-3	75.07	0.25	11.53	2.09	0.04	1.06	2.72	2.08	3.56	0.08
KR5-1	74.08	0.22	11.74	2.12	0.03	1.34	2.13	2.34	3.87	0.11
KR5-2	72.12	1.79	11.67	4.89	0.12	1.49	3.10	1.83	3.02	0.13
KR5-3	77.27	1.18	10.53	3.39	0.08	0.89	2.20	1.91	3.15	0.10
KR5-4	80.17	0.45	10.18	2.03	0.05	0.76	1.96	1.96	3.19	0.09
KR5-5	30.76	22.42	7.48	29.75	1.20	1.57	2.11	0.48	0.71	0.16
KR6-1	44.51	0.13	5.18	2.40	0.11	1.52	21.70	1.55	2.08	0.10
KR6-2	57.16	0.05	6.86	1.50	0.07	0.98	14.49	1.74	2.97	0.08
KR6-3	43.23	2.18	5.50	5.17	0.21	1.88	20.65	1.80	1.75	0.21
st.deviation	14.01	4.54	1.74	5.80	0.24	0.41	5.69	0.38	0.69	0.04
mean	70.60	1.40	9.36	3.13	0.10	0.83	4.58	1.92	2.98	0.09

Italian law D.Lgs. 152/2006

Elements	*A Limit value (mg/kg)*	*B Limit value (mg/kg)*
Sb	10	30
As	20	50
Be	2	10
Cd	2	15
Co	20	250
Cr (tot)	150	800
Ni	120	500
Pb	100	1000
Cu	120	600
Se	3	15
Sn	1	350
V	90	250
Zn	150	1500

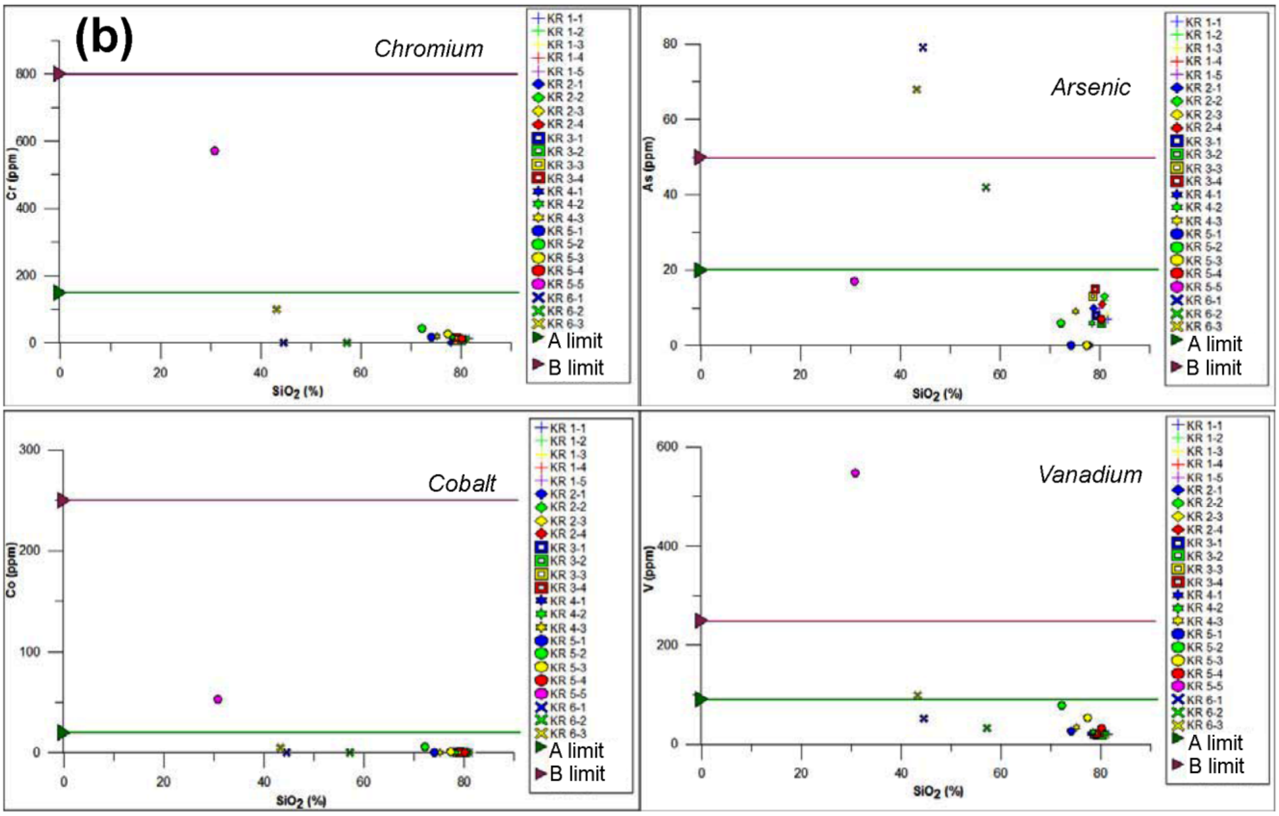

Fig. 3 – a) Major element concentrations (in oxides wt. %) obtained by XRF analysis. b) Correlation diagrams Cr, As, Co, V vs SiO_2. In the diagram are showed the A and B limits of D. Lgs. 152/2006.

CONCLUSION

Analysis carried out on the beach sediments between Crotone and Strongoli towns allow us to obtain suitable informations on the environmental pollution of this coastal sectors. The enrichment in heavy metals as Ti, Fe, Ni, Co, Ce in sample KR 4-1 , KR 5-5 and KR 6-3, and also in V in the last two samples, can be explained with the occurrence of iron and magnesium minerals where these elements are probably hosted. However the same samples display concentrations value higher than the limits reported in D. Lgs. 152/2006 for As, Co and Cr. It is noteworthy that samples KR 5-5 and KR 6-3 refer to a dark coloured layer enriched in heavy minerals, whose origin can be related to the high energy beach environments (i.e. placer deposit). The As anomalies is recorded only within samples of the KR6 sector, located close the Crotone harbour. In this sector, the low waves action due to the presence of harbour dock amplifies the concentration of pollution related to anthropogenic activities.

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