

Comparison of Gravity and Vibro Corer for Acquisition of Environmental Data in Highly Impacted Areas. The Case of Augusta Harbor (Eastern Sicily, Italy)

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Abstract –Sediment cores may be used to reconstruct the chronological evolution of contamination in impacted areas and deep core levels may be used as reference conditions for the assessment of environmental status. For this, it is necessary to collect undisturbed cores, in which textural and chemical characteristics of each analyzed sediment layers correspond to the environmental conditions of the deposition times. Several devices are available and, among these, vibro and gravity corers are the most used ones. In this study, chemical (Ba, Hg, PCBs and PAHs) and grain size data obtained by means of gravity (SW-104) and vibro (Rossfelder[®]) corer from 3 stations of the heavily contaminated Augusta harbor were considered. They were compared considering the different technical characteristics of the corers, in order to demonstrate which is the difference for the data acquisition in terms of penetration depth. The results show that, for areas characterized by high sedimentation rates, the vibrocorer results the best choice for the higher penetration capacity. As regards sediment compaction and potential downward drag of any contaminants, the two devices do not show significant differences.

I. INTRODUCTION

The study of chemical and textural characteristics of sediment cores is an important tool to highlight the anthropogenic impact in marine coastal systems, because they preserve the record of sedimentary and chemical input, due both to natural and anthropogenic factors. Deep core levels reflect environmental conditions before the impact and, consequently, they may be used as reference conditions for the assessment of the environmental status [1]. Due to these features, sediment cores are also the mean to determine background concentrations of metals and trace elements in marine sediments [2].

The sampling method is of basic importance to acquire reliable data, because the collected samples should be

virtually undisturbed, while any devices could be the cause of some disturbance during penetration into the sea bottom.

Two replicate cores from three stations (AU3, AU9 and AU10) of the coastal area of the Augusta harbor, sampled in the context of a comprehensive environmental characterization finalized to identify extent and chronology of contamination, were considered for this study (Fig. 1).

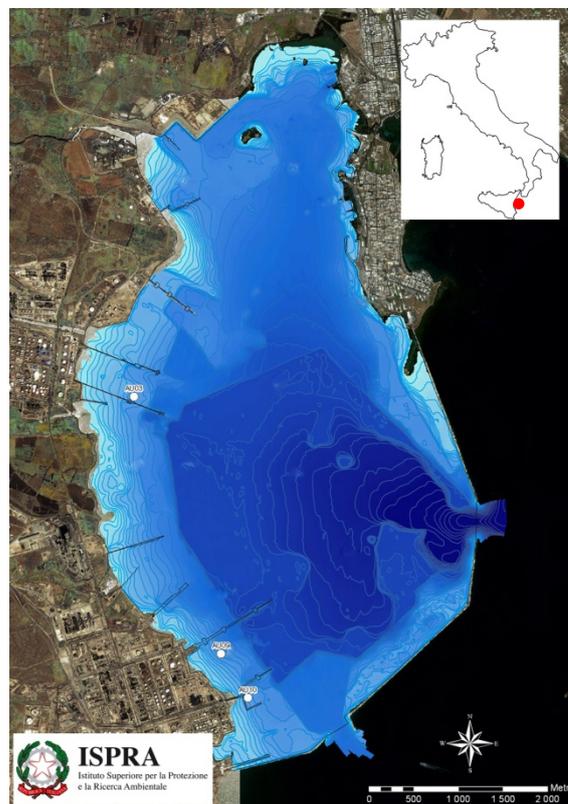


Fig. 1. Study area and sampling stations.

Surface sediments of the Augusta harbor range between sand and silty clay; silt and clay are the prevailing

fractions, with the highest values in the northern sector, while sand reaches higher values nearshore, in the central sector, and close to the southern inlet (Fig. 2) [3].

The harbour area developed into a significant industrial Mediterranean pole from the 1950s onward and became a major processing centre for petrochemicals and chemical industry precursors. The high concentration of these industries and their discharges imposed a pollution legacy on the bay that has become a significant concern. Several industries such as chemical and petrochemical plants, oil refineries and electric power plants have impacted the area for several decades, but one of the most important contributors of hazardous waste to the harbor was from a Mercury Cell Chlor-Alkali Plant (MCCAP) that operated from 1958 to 2003. Recent studies of the area have established the vertical and spatial distributions of some metals (Hg and Ba), PAHs, HCB and PCBs and found the highest concentrations in the southern sector [4].



Fig. 2. Contour maps of sand, silt and clay content in surface sediments.

Aim of this study is to highlight advantages and disadvantages of both gravity and vibro corer for data acquisition finalized to the historical reconstruction of contamination patterns. This goal is achieved taking into account different technical characteristics and different physical principles used for sediment penetration, and by comparing vertical profiles of sediment parameters such as grain size and heavy metal concentration, obtained using the two devices.

II. TECHNICAL FEATURES OF CORERS

For this study the gravity corer (SW104) and the vibro corer Rossfelder® (VBR) were utilized (Fig. 3).

The SW104 gravity corer is a suitable device for sampling mainly muddy sediments, but also the sandy ones; the corer used in this study was equipped with core tube containing a internal liner, 135 cm in length, with 104 mm internal diameter. The core sediment and bottom water are contained through a lower barrier of duck closing device and an upper water-containment valve. The core tube supports the dead weight, which provides the kinetic energy needed to penetrate sediments, and the governor, that controls the vertical descent of the corer, which generally occurs at speed ranging from 0.2 to 1 m/sec. At the end of the tube, the stainless steel nose is composed of a very sharp conical tip, to facilitate the penetration into the seabed [5, 6].

The Rossfelder® vibrocorer is commonly used to collect cores in any type of sediments, and has an electric-powered mechanical vibrator at the head end, which applies thousand of vibrations per minute to help the nose to penetrate the sediment. The vibrocorer incorporates a tight-sealing water-escape valve mounted within the vibro-head, while a core catcher holds the corer during recovery [7]. At the base of the tube there is a square base allowing vertical penetration in sediments. An internal liner having 90 mm internal diameter and 300 cm in length, was utilized for the sampling of the sediments in the Augusta harbor.



Fig. 3. Rossfelder® vibro corer on the left and SW104 gravity corer on the right (Photo by ISPRA).

III. MATERIAL AND METHODS

Gravity cores were sub-sampled by extrusion, while vibro cores were sampled following longitudinal splitting. Samples for geochemical and grain size analyses were carried out on 3-cm resolution. Parameters considered for this study were grain size, Mercury (Hg), Barium (Ba), Polychlorobiphenyls (PCBs) and Polycyclic Aromatic Hydrocarbons (PAHs). Analytical methods were reported by previous studies of sediment contamination of the Augusta harbor [4; 8].

The cross correlation was applied to the two series of data acquired by SW104 and VBR at the same station, as a measure of similarity as a function of the displacement of one relative to the other [9].

IV. RESULTS AND DISCUSSION

The comparison of vertical profiles, in gravity and vibro cores, of grain size, Ba, Hg, PCBs and PAHs in AU3, AU9 and AU10 stations, allows to make some considerations on advantages and disadvantages of the two different corers.

The penetration of VBR allows to sample the deeper

levels than SW104. Especially for AU3 and AU9, below 150 and 140 cm, respectively, the use of VBR allows sampling the older uncontaminated sediments which may be considered as reference conditions (Fig. 4). The natural section of cores is characterized by low and scarcely variable concentration of metals and organic contaminants. The age of these levels, according to sedimentation rates determined by a previous study for cores AU3 and AU10, are older than 1950, when industrial activities started [4]. The recovery of sediments not affected by anthropogenic influence is of basic importance for the environmental assessment, which identifies the extent of deviation from natural condition, and for the identification of local background levels of metals and trace elements [10].

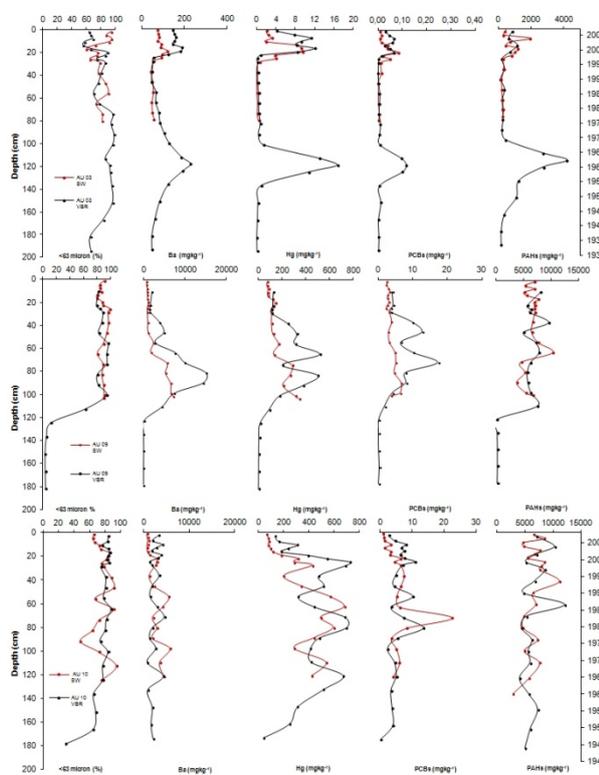


Fig. 4. Downward profiles of $<63 \mu\text{m}</math> sediment fraction, Ba, Hg, PAHs and PCBs in SW104 and VBR replicates at AU3, AU9 and AU10 stations.$

In general, for each analytical parameters, profiles of the SW104 and VBR are rather well aligned for cores sampled in AU3 and AU9 stations, although concentrations of metals and organic contaminants are always higher in the VBR core at AU9 station. Differences in concentration values could be explained only considering that contamination is patchy distributed at AU9 station [8].

The cross correlation was applied to the two series of the same parameter in order to compare the similarity of the SW104 and VBR profiles, also taking into account

the possible lag of one signal relative to the other, due to different sediment compaction of two devices [11]. Cross correlation of Ba profiles was shown as an example (Fig. 5); high correlation values indicate a good agreement of the two profiles. The highest correlations values, concentrated not around the 0 value of lag, but at slightly positive values, indicate that the second profile, that of VBR, is only a little shifted towards the top, with respect the profile of SW104. From this, it may be deduced that the slight sediment compaction recorded for VBR core, due to the lower core diameter, scarcely affects concentration patterns [5]. Cross correlation, showing a slight shift towards the core top of VBR profiles, testifies also that no downward transfer of contaminants is recognizable in the VBR core.

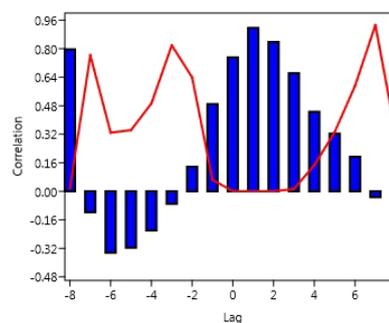


Fig. 5. Output of cross correlation applied on Ba data of the SW104 and VBR replicates at AU3 station (blue bars are correlation values; red lines are p values).

V. CONCLUSION

The high sedimentation rates usually existing in marine coastal settings which need environmental characterization, such as harbor areas, imply the need of using a corer with higher penetration capacity, in order to sample ancient uncontaminated levels which correspond to reference conditions. For this aim, the VBR is undoubtedly superior to SW104. As regards possible sediment compaction and downward shift of contaminants, cross correlation demonstrated that no evident differences between the two devices are recognizable.

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