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A RESEARCH LABORATORY FOR COASTAL AND SEA WATER POLLUTION MONITORING

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Abstract: This paper aims to describe the activities of the Research Laboratory "*Marine measurement for energy production from renewable sources*" of the University Mediterranea of Reggio Calabria, Italy. The research project has been funded by the European Union with the funding scheme *PON 2007-2013*. The Laboratory has been projected and developed in order to carry out research activities in the field of the Energy Production from Renewable Sources and Energy Valorization. The Laboratory activities concern in addition the environmental coastal monitoring and water pollution monitoring. The paper describes the facilities of the Research Laboratory and its technological equipment.

Keywords: marine measurements, energy production, renewable sources, environmental monitoring, coastal monitoring, sea pollution.

1. THE LABORATORY

The Research Laboratory "*Marine measurement for energy production from renewable sources*" of the University Mediterranea of Reggio Calabria-Italy, has been built on the Sea Coast of Reggio Calabria City, Italy, in front of Sicily Sea. The building covers an area of 600 m^2 with a sea area of about 3000 m^2. Inside two specialized laboratories carry out research activities on Energy Production, Environmental Measurement and Sea/Coastal Monitoring. The external and internal building structures have been realized with wood to minimize the environmental impact.

Fig. 1. The Laboratory site.

In detail, the technological equipment allows the laboratory to perform electrical, mechanical and thermal measurements, environmental measurements on air and water pollution and electro-smog monitoring.

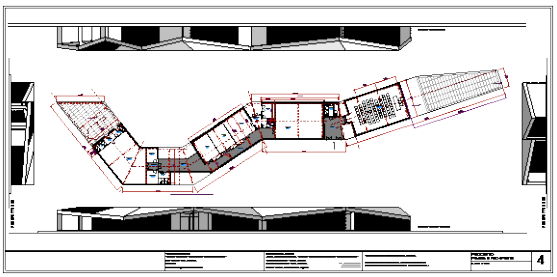

Fig. 2. The floor plan of the Laboratory.

Fig. 3. The Laboratory Project.

The Laboratory performs environmental studies and provides technical support to local governmental authorities and agencies working in the field of environmental regulation and protection.

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2. MARINE AND COASTAL MONITORING

The Laboratory is provided with a mobile unit or craft which allows to perform measurements on sea. Two sonar systems (*MultiBeam* and *Side-Scan Sonar*) are able to make bathymetric measurements and to analyse the morphology of the sea bottom in order to create maps and profiles of the underwater relief.

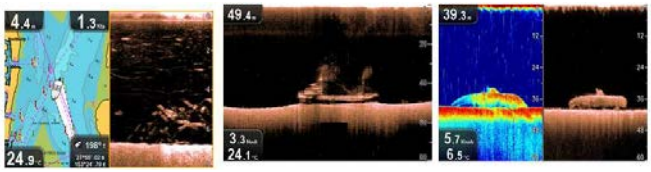

Fig. 4. Bathymetric measurements.

The study of sea depth allows to analyse the stratigraphy of the sea bottom by means of a *Sub Bottom Profiler*. In detail, the craft can perform bathymetric studies and investigations on the marine morphology until 50 m of depth. In addition, a *Laser Scanner* with a range of 1 km allows to carry out accurate topographical measurements of the shoreline and seaside, [1], [2].

Lunghezza fuori tutto LOA:	9,58 mt.
Lunghezza totale LH (ISO 8666):	9,41 mt.
Larghezza BH (ISO 8666):	2,98 mt.
Altezza di costruzione Scafo:	1,70 mt.
Immersione a peno carico:	0,50 mt.
Dislocamento a secco(ISO 8666):	4,30 Ton.
Dislocamento a pieno carico:	6,25 Ton.
Motorizzazione massima	1 x 270 Kw
Materiale scafo:	VTR
Capacità combustibile:	580 Lt.
Capacità acque dolce:	117 Lt.
Capacità acque nere:	56 Lt.
Massimo n° di persone:	20(C) – 12(B)
Velocità massima:	24 Kn
Categoria di progettazione:	C - B

Fig. 5. The Craft.

3. ENVIRONMENTAL POLLUTION MONITORING

The craft by means of the measurement instrumentation on board is able to perform coastal and sea monitoring in order to characterize and detect air and water pollutants, [3]. A set of multiparametric probes measures the concentration of specific physical-chemical polluting compounds in sea water. By considering the extension of the area to be monitored, the measurement campaigns are performed by using a geographical partitioning algorithm, in order to manage easily the computational burden. In detail, the monitored sea area is divided in several zones. The number and size of the zones are not constant but variable and configurable according to needs and requirements.

Fig. 6. Area partitioning algorithm.

Care is paid about the determination of the dimension of the single zone to guarantee a suitable representativeness of the measurement process about the pollution status of the whole area. The wide extension of the investigated area is such that the single measurement sample is able to provide partial information only on a restricted zone or portion of the whole area. Consequently in order to obtain an accurate overview about the pollution status of the area, a sensor data fusion procedure is used. This approach is essential when such a wide area must be monitored, [4], [5]. It allows a more efficient interpretation of data avoiding false alarms and maximizing the available information. In addition, chemical probes can provide false alarms due to the continuous operating state, so faults may happen. The sensor data fusion is able to extract as accurately as possible detailed information from noisy measurements. In addition, a reliable sampling plan requires the definition of the severity level chosen for each partitioned zone. According to the severity level, the proposed procedure provides the size n_i of the measurement points to be acquired in the *i-th* zone. The fixed severity levels and consequently the sample size depend on the presence of sensible targets near to the zone such as inhabited centers, protected species of fauna and flora, etc… As a consequence, sensible zones will be monitored with more accuracy. The data fusion procedure provides a final pollution report on the entire monitored area providing a map of the warning zones.

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Moreover, the craft is equipped with an infrared thermal camera to monitor the contamination of surface sea water due to dispersed oil and organic viscous pollutants. Petroleum and oily organic compounds are hazardous pollutants which put at risk sea coast and water. Such compounds are even dangerous for the marine fauna and flora. In detail, any object is able to absorb or emit thermal energy in Infrared (IR) range if its temperature is over the absolute zero, [6]-[8]. IR spectral range is part of the electromagnetic spectrum near to the visible light. The IR interval is 0.78 μm – 1 mm, see Figure 7 for reference.

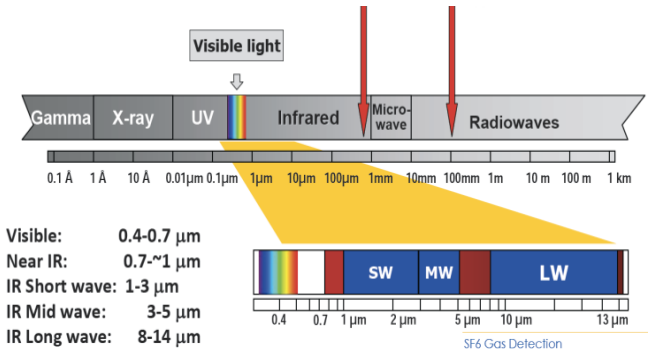

Fig. 7. Electromagnetic spectrum and IR band, [9].

The figure shows the classification of the different infrared sub-bands: near IR, IR short wave, IR mid wave and IR long wave. Thermal energy is in specific percentages absorbed, reflected, refracted or emitted by any object. These percentage values depend on the object features and characteristics (material, temperature, environmental conditions…). We can evaluate the radiance *W* of the object by means of Planck's Radiation Law:

$$W(\lambda, T) = \frac{2\pi hc^2}{\lambda^5}\left[\exp\left(\frac{hc}{\lambda kT}\right) - 1\right]^{-1} \quad (1)$$

where λ is the wavelength of radiation, T the thermodynamic temperature of the object, h is the Planck constant, c is the velocity of light in vacuum, k is the Boltzmann constant.

In order to quantify the amount of radiated energy, the specific emissivity of the object must be known. The emissivity ε_λ can be estimated by the equation:

$$\varepsilon_\lambda = 1 - \tau_\lambda - \rho_\lambda \quad (2)$$

where τ_λ is the transmittance and ρ_λ is the reflectance of the object. Passive thermography allows to detect the thermal energy emitted by the object in IR range by means of an infrared thermal camera. The camera measures the radiance of the object, and specific algorithms convert it into temperature values pixel by pixel.

The proposed technique takes advantage of the different behaviour of diverse compounds during the emission of infrared energy. In detail, water and oil have different emissivity. This allows an infrared camera to detect the two compounds as objects having a different temperature even in presence of thermal equilibrium.

Thermographic images are so used to detect oily and organic viscous pollutants which are not visible at naked eye. The thermal image shows clearly the shape, extension and direction of propagation of the pollutant. In this way, it is possible to predict the pollutant propagation so to support the decontamination activities on the area.

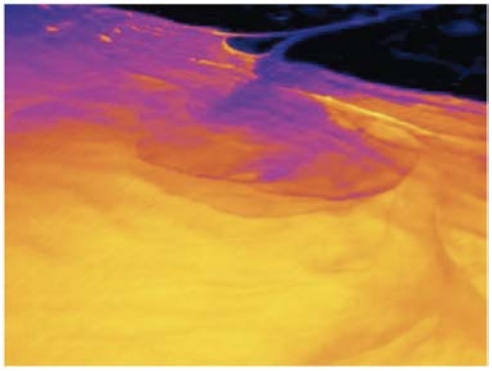

Fig. 8. Thermal image of oily pollutant contamination.

4. MARINE ENERGY PRODUCTION

The Laboratory team carries out research and study activities on coastal erosion by analysing the coastal morphology and the shoreline evolution over time. Further studies on the sea state and the wave generation mechanism are made in order to project and develop innovative energy production systems from wind, wave and marine currents. Sea wind farms today are installed more and more off-shore because of the presence of high winds without any kind of obstacle. This improves the efficiency of the plant. However, implementation and maintenance costs of offshore wind farms are higher than those of onshore ones. In addition, several technical problems rise concerning the anchoring at the sea bottom and the corrosion due to sea water and salt.

An interesting alternative is offered by floating systems. The Laboratory is got involved in a research project which aims to design and develop an alternative prototype of an innovative wind turbine, see Figure 9 for reference.

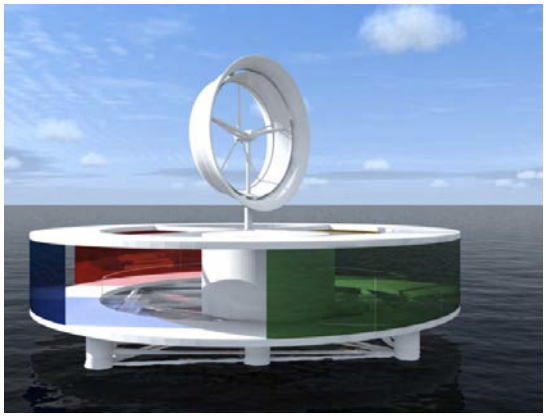

Fig. 9. The prototype of the wind energy generation system.

The plant has been project to produce 30 kW of electrical energy. Its particular architecture allows to maximize the efficiency of the generation plant by tracking constantly the wind direction.

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5. CONCLUSIONS

In the paper, the research activities of the Laboratory "*Marine measurement for energy production from renewable sources*" of the University Mediterranea of Reggio Calabria-Italy have been presented. The paper has just the aim to disseminate the goals of the research project which has funded the construction of the Laboratory. The Laboratory has been built in a strategic geographical position in front of Sicily Sea. Its exploration area includes the Mediterranean and the Ionian seas in the south Italian region.

The Laboratory carries out environmental studies and provides technical support in the field of environmental protection and pollution monitoring in marine environment.

The main research interests are: studies on marine and coastal morphology, sea pollution monitoring, coastal erosion, marine energy production, bathymetric studies and marine explorations. The main measurement instrumentation includes a thermal imaging camera, a multibeam sonar, a side-scan sonar, a sub bottom profiler, a laser scanner and a craft.

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