

## Monitoring of an integrated system for the treatment and disposal of wastewater from the cleaning processes of vessels in the Marina of Agios Nikolaos, Crete, Greece

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### INTRODUCTION

The Marina of Agios Nikolaos (35° 11' 10'' N, 25° 43' 00'' E) is a well-protected marina in all weather conditions. It is built to European standards and can accommodate up to 255 boats per year. The marina of Agios Nikolaos is located in the heart of the city and provides easy access to the center of the town, the main archaeological sites and other places of interest. The facilities of the Marina offer a variety of options and specialized services, including the boat washing service.

As a result of the location, the satisfactory load of vessels and the Environmental Policies, an integrated system for the treatment and disposal of wastewater from the cleaning processes of vessels should be designed and installed. In the current report, a summary of the installation study and the operation of the wastewater treatment system is presented, accompanied by laboratory monitoring results.

### THE PROBLEM OF ENVIRONMENTAL POLLUTION & THE SOLUTION

The problem of heavy metals found in small quantities in sediments in the sea and some samples collected from the Marina, is related to the problem of cleaning, maintenance and repair of vessels.

In order to tackle this issue, the approach was to develop and apply a treatment system for the wastewater produced from the cleaning processes of vessels. The scope was to effectively reduce the pollutants resulting from the above activities, as well as consider the possibility of reusing the processed wastewater produced.

### INSTALLATION, OPERATION AND MONITORING OF THE INTEGRATED TREATMENT SYSTEM

According to the relevant technical study that preceded and adapted to the requirements of the specific, facility an integrated system was installed. The system consists of a set of plumbing and electrical installations for the treatment of wastewater following the technique of chemical coagulation. For selecting the optimal chemical treatment of wastewater, experimental tests were carried out. Among the reagents that were tested, the best results were obtained by using aluminum sulfate ( $Al_2(SO_3)_4$ ) in an optimal dosage of 1.25 g/L in combination with DF974 polyelectrolyte in an optimal dosage of 0.5 g/L. Corrections of pH were made when necessary, using caustic soda solution.

The system was put into operation and the chemicals were

produced on a daily basis, depending on the requirements of the facility. A sampling and analysis plan was designed and implemented, in order to monitor the system and evaluate its operation performance. Results of laboratory tests as obtained from a 3-month monitoring period are summarized in **Table 1**.

All tests were conducted by an accredited laboratory according to ELOT EN ISO/IEC 17025.

**Table 1.** Analytical results from monitored quality parameters for a 3-month operation period of the integrated treatment system in Marina of Agios Nikolaos.

Parameter (Units)	Wastewater Mean $\pm$ SD	Treated eluent Mean $\pm$ SD	% reduction
pH	6.6 $\pm$ 0.1	7.0 $\pm$ 0.1	-
C.O.D. (mg/L)	166 $\pm$ 37	54 $\pm$ 14	67.6%
T.S.S. (mg/L)	88 $\pm$ 18	16 $\pm$ 3	82.2%
Cadmium, Cd ( $\mu$ g/L)	70 $\pm$ 60	8 $\pm$ 3	88.5%
Chromium, Cr ( $\mu$ g/L)	18 $\pm$ 8	8 $\pm$ 4	58.3%
Copper, Cu ( $\mu$ g/L)	11946 $\pm$ 4502	1120 $\pm$ 139	90.6%
Iron, Fe ( $\mu$ g/L)	2585 $\pm$ 939	211 $\pm$ 49	91.8%
Lead, Pb ( $\mu$ g/L)	193 $\pm$ 109	19 $\pm$ 1	90.4%
Manganese, Mn ( $\mu$ g/L)	234 $\pm$ 6	168 $\pm$ 43	28.4%
Nickel, Ni ( $\mu$ g/L)	59 $\pm$ 23	45 $\pm$ 12	24.6%
Zinc, Zn ( $\mu$ g/L)	16520 $\pm$ 5247	5807 $\pm$ 666	64.8%

SD: Standard Deviation

### CONCLUSIONS

According to the results of tests carried out during the monitoring period of the wastewater treatment system in the Marina of Agios Nikolaos, the applied system removes pollutants from 24.6% (for nickel) up to 91.8% (for iron). It is important to note that a satisfactory reduction of more than 58.3% in 6 of the 8 heavy metals monitored was achieved. Also, satisfactory reductions of 67.6% for the chemical oxygen demand (C.O.D.) and 82.2% for total suspended solids (T.S.S.) were observed. Finally, the treatment did not result in extreme alterations of pH value. As a result, it is necessary to monitor the system on a permanent basis, especially for periods where there is a greater burden on the facility, in order to ensure the protection of the aquatic environment and surroundings from pollutants resulted from such facilities and processes.