Regi Lagni: Revamping of the Wastewater Treatment Plant "Area Nolana" Without Service Interruption

In Summer 2010, ENEA was involved in a project aimed at mitigating water pollution in the network of drainage channels known as "Regi Lagni", as well as in the coastal areas near the city of Naples. The innovative experience hereby presented consisted of proposing an ad hoc procedure to avoid bypassing non-treated or partially treated wastewater during the different steps of works for revamping the plant. Namely, in this paper we synthetically describe the procedure "Zero discharge in Regi Lagni", engineered by ENEA, based on five micro-interruptions of strategic plant sections, during which influent flow (say, 3,000 m3/h) was stored in internal volumes of the plant. The experience has shown that, with a limited increase in costs (less than 1% of the total value of the revamping project), great advantages can be achieved for the environment

Raffaele Pica, Francesco Pasanisi, Carlo Tebano, Antonio Salluzzo, Gianpiero Cesàro

Regi Lagni: Potenziamento dell'impianto di trattamento delle acque reflue "Area Nolana" senza interruzione del servizio

Nell'estate 2010 l'ENEA è stato coinvolto in un progetto finalizzato alla mitigazione dell'inquinamento nella rete di canali dei "Regi Lagni" e delle aree costiere in prossimità della città di Napoli. L'esperienza innovativa che viene qui presentata è consistita nella proposta di una procedura ad hoc per evitare il bypass di acque non trattate o solo parzialmente trattate durante le varie fasi dei lavori di potenziamento dell'impianto. Nel presente lavoro si descrive sinteticamente la procedura " scarico zero nei Regi Lagni" messa a punto dall'ENEA, basata su cinque micro interruzioni su sezioni mirate di impianto, durante le quali la portata in ingresso (ca. 3.000 m^3/h) è stata accumulata in volumi disponibili all'interno dell'impianto. L'esperienza ha dimostrato che, con un limitato incremento dei costi (meno dell'1% del valore totale del progetto di potenziamento), è stato possibile conseguire grandi benefici per l'ambiente

Coherent with its mission, over the last decade ENEA has been involved in environmental protection in Campania Region[1]. In particular, from 2006, efforts of ENEA focused on the network of five big wastewater treatment plants discharging into the drainage channels network named "Regi Lagni" and coastal area named "Litorale Domitio"[4].

In this framework, new technical/managerial aspects about a new connection plan are presented, dealing with the startup of a new biological treatment line in the Area Nolana plant, aimed at increasing the volume

Raffaele Pica, Francesco Pasanisi, Carlo Tebano, Antonio Salluzzo
ENEA, Technical Unit for Portici Technologies, Chemical Environment Laboratory

Gianpiero Cesàro
Director of "Area Nolana" municipal wastewater plant

of wastewater conveyed to the secondary treatment facility.
The mentioned procedure was based on the criterion of " zero discharge" of non-totally purified wastewater. The operation initially appeared difficult to perform, due to the value of the inlet flow, approximately 3,000 m^3/h. Actually, the perfect execution of the project permitted to avoid the discharge of out-of-standard water in the Regi Lagni channel, all over the connection procedure in summer 2010.
The wastewater treatment plant "Area Nolana" is located in Marigliano, in the province of Naples. It was built at the beginning of the 80's by the Cassa per il Mezzogiorno (CASMEZ), a governmental agency for the development of Southern Italy, within the framework of the so-called "Special Project no. 3-Remediation of the Gulf of Napoli", after a dramatic cholera epidemic. The plant takes up a surface of 20 hectares and treats the wastewater of 34 towns near the city of Nola. The size of the plant is around 461,000 population equivalent and the wastewater is generally of urban origin and, in lower fraction, coming from the near industrial area of Nola-Marigliano. The final discharge of the treated wastewater is in the upstream part of the Regi Lagni canal, about 50 km far from the mouth on the coast called Litorale Domitio. The Area Nolana plant is located in the Northern part of the Campania plain, marked by the Mount Fellino in the North, by the Southern versant of the Mount Partenio in the East, and by the volcanic mountains of Somma–Vesuvio in the South (Figure 1).
The purification cycle is based on the mechanical and microbiological treatment of the wastewater. This means that the pollutants are removed by screening, settlement and filtration, while the dissolved fraction of pollutant is removed by micro-organisms present in the sludge, as in the conventional process of "activated sludge plant"[2],[3]. Today's layout of the plant refers to the original design of the CASMEZ, later implemented in the biological treatment to fulfill the latest legislation requirements. In fact, from 2006, a third biological line has been introduced and the section for the denitrification system adapted. In 2008, a final microfiltration section has been introduced (tertiary treatment).
The cycle of the water treatment is illustrated in Figure 2.

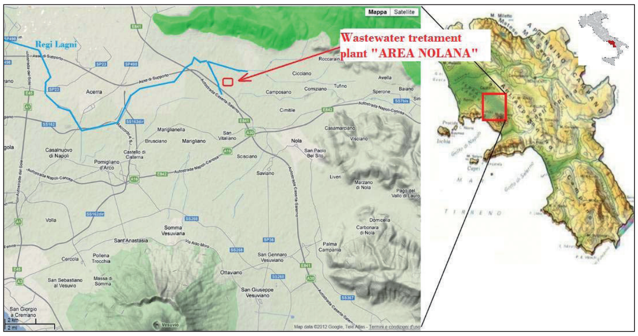

FIGURE 1 Geographic position of the wastewater treatment plant called "Area Nolana"

Between 2006 and 2010, the plant suffered a critical condition due to the difficulty to admit the whole influent flow to the biological section[5]. Therefore, as a result of the daily peaks in flow, even in dry days, fractions of only partially treated water were discharged in bypass, causing a possible contamination of the final current (Figures 3 and 4).
ENEA was involved in the solution of the mentioned problems, supporting the revamping project and collaborating with technicians of the Regione Campania Water Department. Moreover, ENEA introduced a new idea for the connection of the new lines avoiding temporary discharge (bypass) of wastewater not completely treated. This connection procedure can be considered as a new approach to the extraordinary maintenance of the wastewater treatment plant in Campania Region, where normally plants in such conditions are simply turned out of service[6].
It must be said that plants like "Area Nolana" are quite common in Italy, especially among the biggest ones; therefore, the executed procedure could be an interesting example to be exported for the extraordinary maintenance of similar plants.

New works and connections

The revamping works concern the construction of a fourth biological line beside the existing three ones currently in service. The new treatment line is basically composed of three tanks:
■ The new distribution tank, which was to be connected

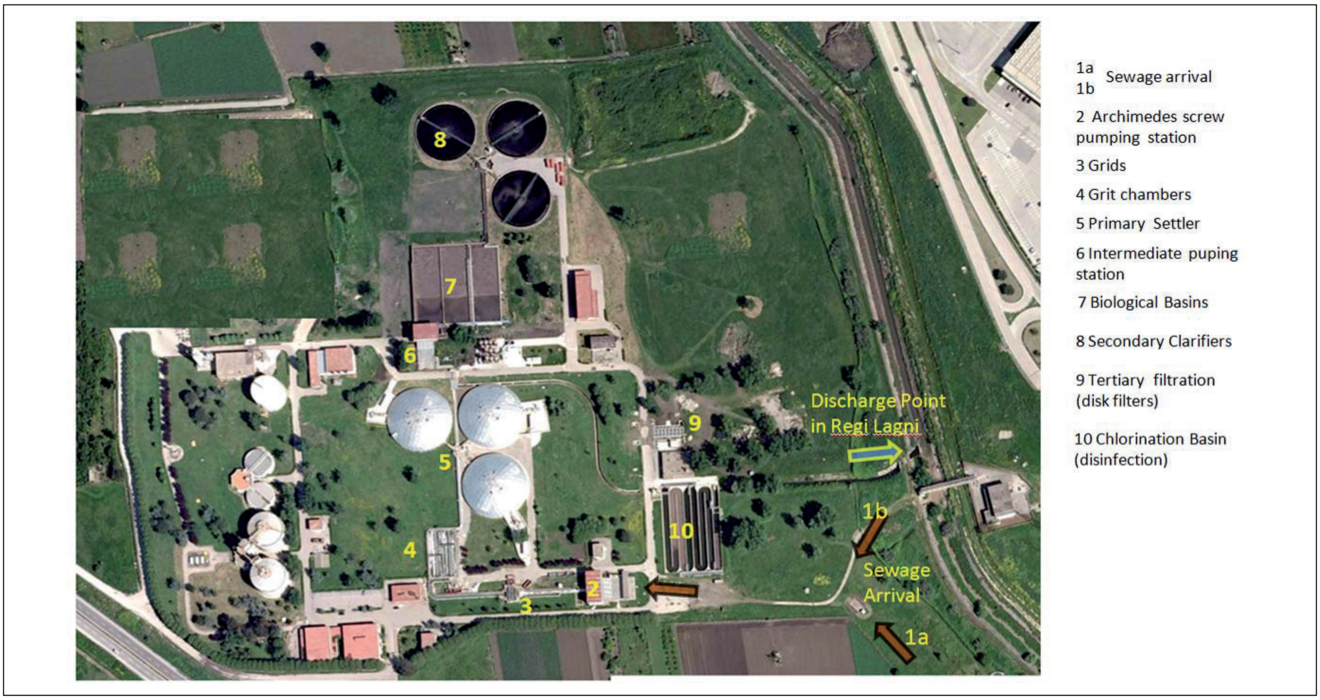

FIGURE 2 Aerial view of the plant with the legend of the main wastewater treatment sections (Water Line)

to the existing one used to feed the existing three lines already in service. The connection was achieved through the construction of a rectangular-sectioned channel. For the start-up of the distribution tank , it was necessary to cut the concrete wall dividing the new channel from the old distributor tank (see Figure 5, point 1).

- The outlet of the new nitrifying/denitrifying tank was connected by joining the new drainage ditch to the existing one. The connection required the removal

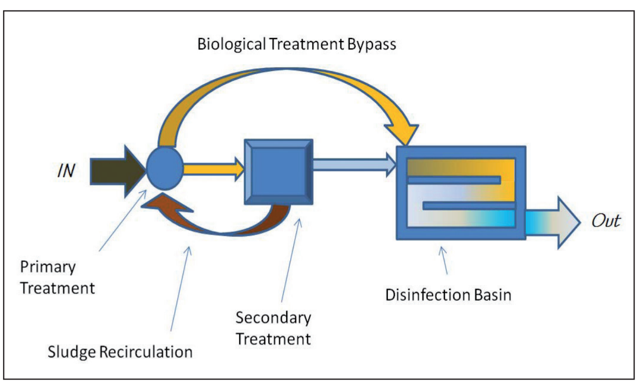

FIGURE 3 Scheme of the effect of biological treatment bypass, resulting in the contamination of clarified water in the disinfection basin

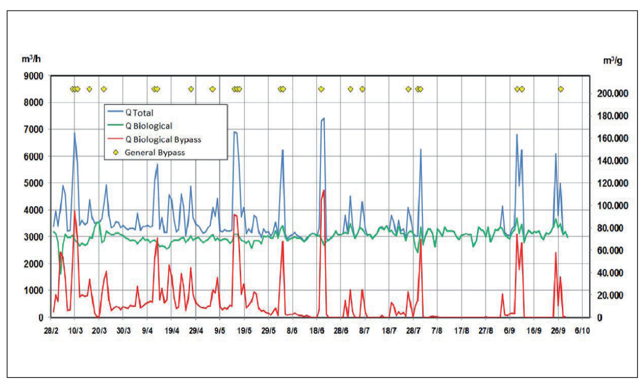

FIGURE 4 Daily incoming flow rate during the period March September 2010. Rainy days are reasonably well indicated by the activation of the general bypass

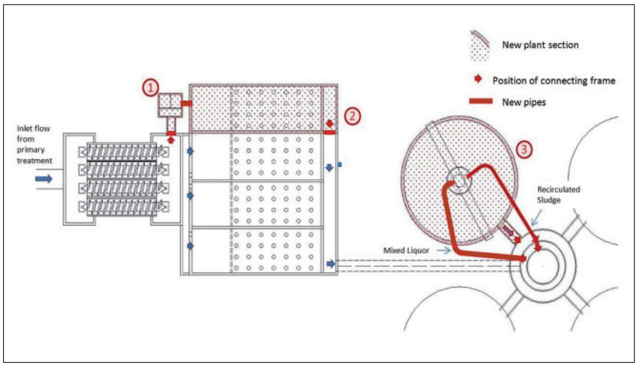

FIGURE 5 Connection scheme of new basins (plant)

of the concrete wall separating the two ditches (see Figure 5, point 2).

- The new secondary settling tank was connected to the existing distributor feeding the three existing settling tanks. In particular, the existing distributor for secondary settling tank is composed of three concentric tanks having the following functions:
  - The central well hosts the concentrated sludge coming from the bottom of the secondary settling tank.
  - The intermediate section hosts the mixed liquor, coming from the biological tanks to be redistributed to the secondary settling tanks.
  - The outer section hosts the clarified water coming from the external ditch of secondary settling tanks, and finally sends them to the final filtration (see Figure 5, point 3).

It was therefore necessary to connect the pipe (DN 700 mm) of the concentrated sludge, coming from the new secondary settling tank to the central wall of the existing secondary distributor. To this aim, a slide gate was installed to control the sludge flow. On the other hand, the connection pipe of mixed liquor (DN 1100 mm) was connected to the intermediate section of the secondary distributor, going under the external section. The clarified water, instead, was connected by a rectangular concrete channel joining the external section of secondary distributor with the new settling tank. The channel was finally built over the two pipes of the mixed liquor (DN 1100 mm) and the concentrated sludge (Figure 6).

Critical aspects of connections without bypass

The entire procedure hereby described was based on the possibility to turn "out of service" the unit interface between the new and the existing ones. The operations were divided into micro-interruptions of functioning systems, while the influent flow was stored inside suitable internal tanks.

The volumes for the temporary storage of the wastewater are indicated in Figure 7 and the main values are summarized in Table 1.

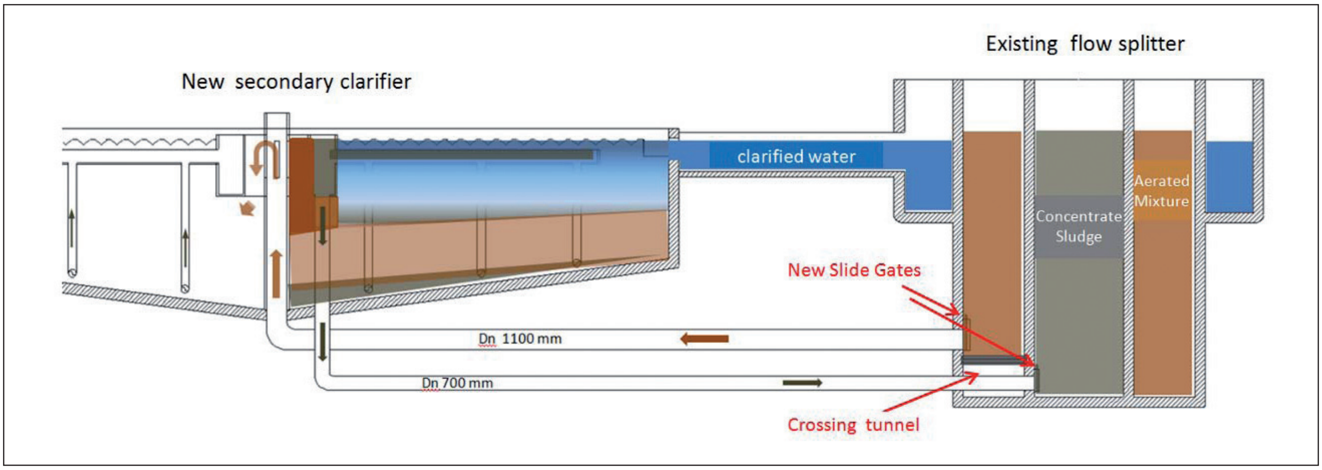

FIGURE 6 Section connection scheme between new secondary clarifier and existing flow distribution chamber (Flow Splitter)

Basin for temporary storage	Volume	Filling time
Primary clarifier	3,300 m^3	1h 20 min
Disinfection basin	2,500 m^3	1h
Fourth biological basin (new)	5,000 m^3	2h
Secondary clarifier (new)	8,750 m^3	3h 30 min

TABLE 1 Main values of temporary storage of the wastewater

The interruption time has been reduced between 2.5 and 8 hours for each step. The duration of the internal suspension of the process has been determined according to the following parameters:

- amount of wastewater inlet flow;
- available volumes for the storage;
- duration of the works necessary for the interconnections;
- weather conditions;
- the need to preserve the biologic and rheologic characteristics of sludge during the suspension, as to maintain the performance and reliability of the process when restarting.

About the inlet flow, the historical data show in the last ten years a severe increase in its overall amount. In fact, influent volumes changed from 9,000,000 m^3/year in 2000 to about 29,000,000 m^3 /year in 2009.
The variability over the year follows the trend of the rainfall and droughts. The 2009 data show a minimum inlet flow in May (about 2.000.000 m^3/month) and a maximum of 3,100,000 m^3/month in March.
In order to determine the best daily time when executing the operation of drainage interconnections, we referred to the daily data of arriving flow. In particular, from the analysis of historical data, the mean hourly trend in influent flow was derived (Figure 8), considering only dry days, discarding all data referred to recent rainfalls (less than 2 days).
From the analysis of the available data, it was noticed that the time of the minimum influent flow is around 09.00 a.m., while the period when the inlet flow is under the mean value of dry periods is between 04.00 and 12.00 a.m.. So, it was decided to perform the activities during this period.

New biological tanks connection procedure

The connection procedures were split in three steps, between July 1st and September 23rd, 2010. The duration of the three steps was reduced from the original 98 days to 73 days by the superposition of the 3 steps.
The different steps are summarized below.

- Step 1 – (duration 10 days) – Connection of the new nitro-denitro basin (Figure 9);
- Step 2 – (duration 43 days) – Connection the new secondary clarifier piping to the flow splitter (Figure 10)

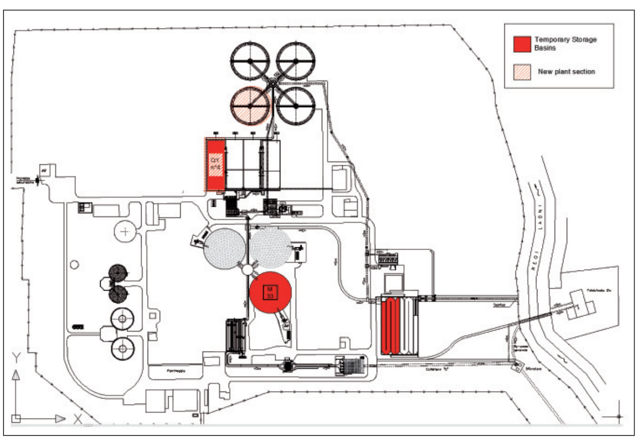

FIGURE 7 Facility plan with indication of the basins used for flow storage during the “micro interruption” programmed for the start-up of new plant sections

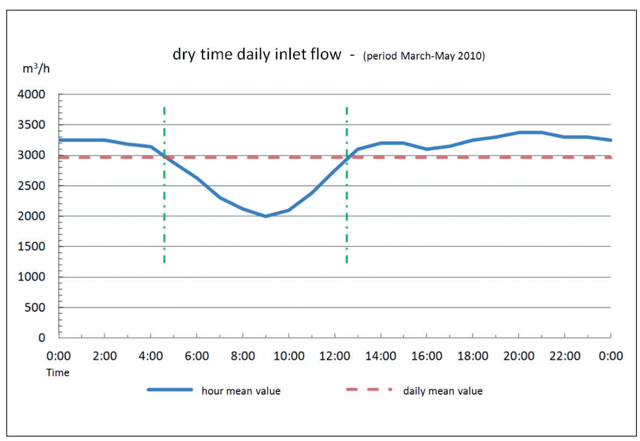

FIGURE 8 A typical trend of influent flow in dry days (hour mean value). Between green bars the daily period chosen for “micro interruption” of the internal plant functioning

FIGURE 9 Connection sequence for junction of feeding flow splitter chamber and new biological basin

FIGURE 10 Crossing channel of intermediate section in the existing flow splitter

FIGURE 11 Connection of the flow splitter to the secondary clarifier (clarified water channel)

- Step 3 – (duration 45 days) completing secondary clarifier connection. In particular, the flow splitter (outside wall) has been connected to the clarifier clean water discharge channel (Figure 11).

A detailed plan was prepared for each step, considering the execution time, materials, working means and special tools. A specific plan was then prepared to analyze the safety aspects for the personnel employed and for the setup of the entire plant. It was possible to limit the "micro-interruptions" number by optimizing the processing times. Within the scheduled days, wastewater was stored inside the basin available in the area of the plant. During the interruptions the basins to be connected were set out of service and temporary drained. Operations were simultaneously performed on several parts of the plant in order to contain the total time of the project, as can be observed in the follow Gantt chart (Figure 12).

The five "micro-interruption" of the plant process are describe in Table 2.

Particular attention was paid in order to maintain the biological sludge in standby and active in the three functioning biological basins. In the days before the one chosen for "micro-interruption", some specific actions were performed to change the process configuration. As an example, the following is a description of the activities in one of the "micro-interruptions" (27/08/2010) (Table 3).

Conclusions

The start-up plan of the new biological line for the revamping of the wastewater treatment plant Area Nolana has been based on the main concept of preservation of water quality in the Regi Lagni and

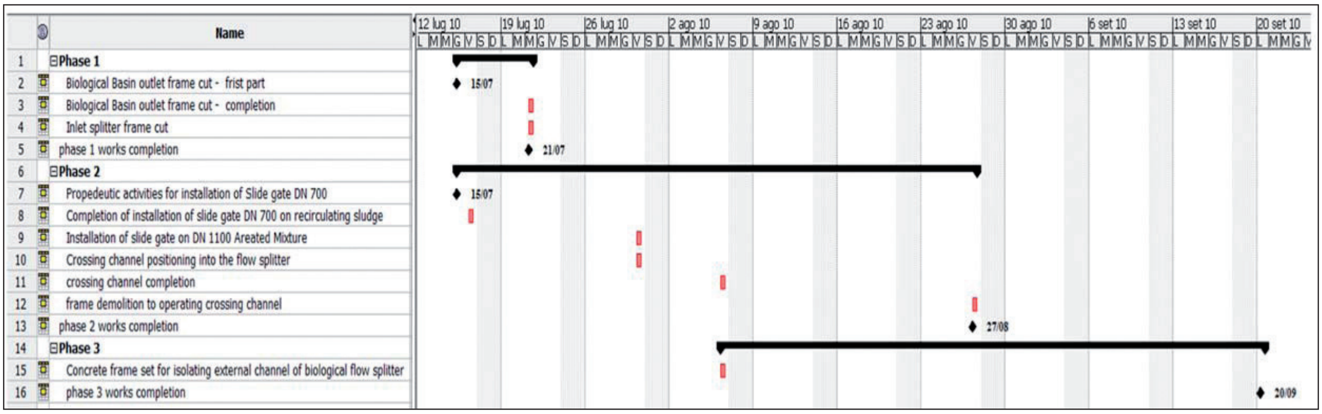

FIGURE 12 Scheduled "micro interruption" (red spots) for the connection of new basins to functioning wastewater treatment plant

along the coast of "Litorale Domitio". A technical and managerial effort has been done in order to avoid the outlet of untreated water in the environment. To reach this goal, ENEA induced the contractor to modify several working, even when already approved by the Regional Water Department. The idea initially appeared hard and consisted of the storage of the inlet flow (3,000 m^3/h) for a sufficient time to perform the work of interconnection of the new biological line with the existing operating lines. Anyway, this new idea was shared among the technicians involved in the operation called "Zero bypass in the Regi Lagni" and this allowed them to be successful. In Summer 2010, while working at the connection of the new line, about 5,000,000 m^3 of wastewater were totally treated and discharged into the environment according to the limits stipulated by the Italian laws. The procedure showed that the problem related to the extraordinary maintenance of the wastewater plants can be solved without interrupting the service. In particular, through

Date	Duration of micro interruption	Volumes of stored wastewater	Job description
Step 1 - 21/07/2010	2.5 h	5.500 m^3	connection of the fourth biological treatment basin to the feeding water splitter
Step 2 - 16/07/2010	5.5 h	11.000 m^3	installation of a DN 700mm gate on waste sludge output pipe from the secondary splitter
Step 2 - 30/07/2010	4.5 h	9.000 m^3	a) Installation of a metallic box to create the crossing channel in the intermediate sector of the secondary splitter b) installation of a DN 1100mm gate on the channel for feeding mixed liquor to the new secondary clarifier
Step 2,3 - 6/08/2010	4.5 h	9.000 m^3	a) completing the crossing channel installation in the intermediate sector of the secondary splitter. b) installation of a temporary concrete frame in order to allow the splitter operation during the subsequent processing of 4° clarifier connection
Step 2 27/08/2010	7.0 h	14.000 m^3	Completing the recirculation sludge pipes

TABLE 2

Time	Management operations
A few days before the start action date	**Primary clarifiers:** primary clarifier No. 1 emptying **Oxidation tanks:** oxidation tank n.4 emptying **Disinfection tank:** first half chlorination tank emptying
2 hours before the startup of micro interruption	**Secondary clarifier and oxidation tanks:** Sludge blanket level reduction in clarifiers by air supply amount to the nitrifying reactors reducing and consequent partial sedimentation of sludge in them
Action day. hour 04:00 (flow about 2,500 m³ / h) Estimated step duration 3.5 h	**Secondary clarifiers:** switch off pumps recirculating sludge and rotating bridge **Oxidation tanks:** Pumping station to the biological reactors works and the mixed liquor feeding the secondary clarifiers that, therefore, accumulate the sludge on their bottom until they occupy a layer equal to about 2/3 of the total available (This arrangement allows to immediately restore the biological sector at the end of the operation)
hour about 07:30 Estimated step duration 2.0 h	**Secondary clarifiers:** Incoming flow to secondary clarifiers is interrupted and no power cut **Oxidation tanks:** The inlet flow fills the empty new tank n. 4, while in the remaining three tanks the aeration works to ensure the biomass survival
hour about 09:30 Estimated step duration 1.5 h	**Oxidation tanks:** the flow to the sector is interrupted. The four tanks are kept in aeration to maintain biomass biological activity **Primary clarifier:** The wastewater flow incoming in the empty primary clarifier
hour about 11:00 Estimated step duration 1.0 h	**Primary clarifier:** at the end of filling all three primary clarifiers works **Disinfection tank:** the outgoing flow from the primary clarifiers goes to the previously emptied chlorination tank through the “by-pass” channel
Hour about 12:00	Within this time, the normal operation completion is guaranteed and all the tanks involved in the procedure restored
In the following days	The stored wastewater is treated in line during the minimum flow rate hours

TABLE 3

a detailed analysis of the volumes, flow and executive procedures, great environmental advantages can be obtained.

As regards costs, the procedure hereby described resulted in only about 0,65% increase in the total cost of the revamping project. Moreover, no additional provisional facility was required compared to the original design.

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