ECOMAWARU

ECO-sustainable MAnagement of WAter and wastewater in RUral communities

D6.1 – A6.1
Technical Report on the achieved results

31st October 2013

Technical report on the achieved results

ACTION 6.1: Analysis of the results

Aciotn 6.1 aims at evaluating the efficiency in terms of pollutant load abatement of the traditional system typically employed for the treatment of wastewater effluent and storm water runoff discharges and at assessing the potential implementation (or even its replacement) of the traditional treatment solutions by the installation of more sustainable treatment unit. Based on the experimental results obtained through the monitoring campaigns carried out in Action 5, a data base containing the quality-performance indexes and the biomass growth indexes has been compiled, in particular the collected data have been elaborated in order to define the nutrients removal efficiency in the microalgae photobioreactor and pond. This database has been compiled in order to support the definition of the guidelines as indicated in the Action 7. As for the storm water runoff the untreated and treated storm water runoff at the site of concern have been characterized and the efficiency of the exiting treatment system (on-line tank) has been assessed. This report is organized in two sections named wastewater effluent and stormwater runoff. In the wastewater effluent section, the quality-performance indexes describing the efficiency in nutrients removal rates and the biomass growth have been evaluated for the photobioreactor with microalgae, closed system, installed at San Pietro Vara and for the pond with microalgae, open system, installed at Le Pezze. In the stormwater runoff section, the analysis of the experimental results has been performed for the Municipal Waste depot pilot site. This action has been implemented by DICHEP (now DICCA- Department of Civil, Chemical and Environmental Engineering).

WASTEWATER EFFLUENT

The experimental data have been elaborated in order to highlight the quality performance index and the influence of seasonal factors on the process and plants.

The parameters that have been individuated as indices are:

1. **The nutrient and organic pollution removal**
2. **The algal growth**
3. **The discharge rules established by Italian and Regional Laws**
4. **The flexibility against organic and nutrients load variations**
5. **The simplicity of management and maintenance**

The first index refers to the ability to remove nitrogen, phosphorus and the organic pollution (COD) using solar energy alone and without the use of chemicals.

The second index refers to the production of biomass that can be used for energy production (biogas / biodiesel),chemicals, animal feed, or as it is as a soil conditioner.

The third index refers to the water discharges that must meet the pollutant concentration limits imposed by law.

The fourth index refers to the system that must be able to withstand variations of nutrient concentrations without collapsing or, even worse, to increase the pollution of the water.

The fifth index refers to the identification of the control and maintenance required to keep the plants at full efficiency.

SAN PIETRO VARA WASTEWATER TREATMENT PLANT

The results of photobioreactor system

The prototype plant treated final effluent of the municipal wastewater treatment plant of S. Pietro Vara. The municipal plant carries out the purification by means of the extended aeration process that operates in the endogenous respiration phase of active sludge growth and operates the denitrification using the organic matter in wastewater (predenitrification). The municipal plant was designed to treat a average flowrate of 48 cubic meters per day of wastewater (300 inhabitans equivalent (IE); 200 liters per day per IE, 0.80 sewage inflow coefficient).
The results reported below refer to the photobioreactor in the final version described in detail in Deliverable 5. The photobioreactor was fed with the final effluent of municipal wastewater treatment plant at a flow rate of 200 liters per hour, corresponding to 10% of the wastewater entering the treatment plant and to a hydraulic retention time of about 5 hours. A greater retention time would have led to the installation of an additional module that was considered not appropriate in this case given the low concentrations of nutrients incoming.
From the results obtained and reported in detail in the tables and graphs below, one can draw the following conclusions related to the performance indices:

the nutrient and organic pollution removal was influenced by meteorological factors (temperature, solar radiation) that, together with the concentration of nutrients, are crucial for algal growth. The tables 6 -7-8 lists all values obtained during the monitoring period. For the whole period the range of removal efficiency was: N-NH_4: 41-91%; P-PO_4: 22-82%; COD: 0-59%.

The algal growth: for algal growth are the same considerations mentioned above. The growth was limited by the low concentrations of nutrients. It is observed that the biomass produced is a bacteria algal biomass with good settleability

The discharge rules established by Italian and Regional Laws: the effluent from the plant always meet the limits established by Italian and Regional Laws and with features that allow the eventual reuse for irrigation.

The flexibility against nutrients and organic load variations: the system has a good flexibility of operation against nutrients and organic load variations provided that does not occur an imbalance between the ratio of the concentrations of the same.

The simplicity of management and maintenance: the system once started does not require special and continuous attention of management. The routine maintenance is required to fed and recirculation pumps and to clean the surfaces exposed to sunlight

photobioreactor								
season	autumn 2012		winter 2013		spring 2013		summer2013	
time	oct-nov-dic		janu-feb-mar		apr-may-jun		jul-agu-sept	
n° samples	10		11		12		12	
	inlet	***outlet***	***inlet***	***outlet***	***inlet***	***outlet***	***inlet***	***outlet***
pH	7.3	7.5	7.1	7.3	7.4	7.7	7.6	8.3
T [C°]	9	14	5	10	14	19	21	26
N- NH_4 [mg/l]	3.68	1.64	2.63	1.34	3.85	0.97	6.15	0.61
P- PO_4 [mg/l]	0.161	0.089	0.201	0.128	0.211	0.096	0.299	0.071
COD [mg/l]	20	16	12	13	24	15	31	16
SST [mg/l]	-	14	-	12	-	51	-	81

Table 1 The average values of the photobioreactor system for the 4 seasons

In these tables the nitrogen has been reported only as ammonium because the concentrations of nitrous and nitrate nitrogen were very low and often non detectable.

N –NH_4 [mg/l] inlet		N –NH_4 [mg/l] outlet		autumn
minimum 1.36	maximum 5.70	minimum 0.65	maximum 2.39	
N –NH_4 [mg/l] inlet		**N –NH_4 [mg/l] outlet**		**winter**
minimum 1.62	maximum 3.97	minimum 0.81	maximum 1.95	
N –NH_4 [mg/l] inlet		**N –NH_4 [mg/l] outlet**		**spring**
minimum 2.90	maximum 4.89	minimum 0.36	maximum 1.95	
N –NH_4 [mg/l] inlet		**N –NH_4 [mg/l] outlet**		**summer**
minimum 4.20	maximum 10.56	minimum 0.38	maximum 1.03	

Table 2 Range of ammonium concentrations at the inlet and outlet from the photobioreactor in the four seasons

$P-PO_4$ [mg/l] inlet		$P-PO_4$ [mg/l] outlet		autumn
minimum	maximum	minimum	maximum	
0.10	0.21	0.04	0.13	
$P-PO_4$ [mg/l] inlet		$P-PO_4$ [mg/l] outlet		winter
minimum	maximum	minimum	maximum	
0.08	0.95	0.06	0.57	
$P-PO_4$ [mg/l] inlet		$P-PO_4$ [mg/l] outlet		spring
minimum	maximum	minimum	maximum	
0.15	0.29	0.07	0.12	
$P-PO_4$ [mg/l] inlet		$P-PO_4$ [mg/l] outlet		summer
minimum	maximum	minimum	maximum	
0.24	0.37	0.05	0.09	

Table 3 Range of phosphorous concentrations at the inlet and outlet from the photobioreactor in the four seasons

COD [mg/l] inlet		COD [mg/l] outlet		autumn
minimum	maximum	minimum	maximum	
12.00	27.00	9.84	20.84	
COD [mg/l] inlet		COD [mg/l] outlet		winter
minimum	maximum	minimum	maximum	
9.00	18.00	7.80	20.00	
COD [mg/l] inlet		COD [mg/l] outlet		sping
minimum	maximum	minimum	maximum	
15.00	30.00	10.50	22.50	
COD [mg/l] inlet		COD [mg/l] outlet		summer
minimum	maximum	minimum	maximum	
29.00	35.00	12.30	20.65	

Table 4 Range of COD concentrations at the inlet and outlet from the photobioreactor in the four seasons

SST [mg/l] outlet		autumn
minimum	maximum	
9.00	18.70	
SST [mg/l] outlet		winter
minimum	maximum	
7.44	17.50	
SST [mg/l] outlet		spring
minimum	maximum	
30.00	70.00	
SST [mg/l] outlet		summer
minimum	maximum	
66.00	97.00	

Table 5 Range of TSS concentrations at the inlet and outlet from the photobioreactor in the four seasons

Nitrogen as ammonium

	$N-NH_4$ [mg/l]		$N-NH_4$ [%]
DATE	*inlet*	*outlet*	*removal*
04/10/2012	5.7	2.39	**58**
11/10/2012	4.9	2.11	**57**
18/10/2012	5.1	2.30	**55**
25/10/2012	4.65	1.95	**58**
08/11/2012	4.01	1.64	**59**
15/11/2012	3.46	1.38	**60**
22/11/2012	3.7	1.89	**49**
29/11/2012	3.21	1.61	**50**
05/12/2012	2.36	1.16	**51**
13/12/2012	1.98	0.95	**52**
20/12/2012	1.36	0.65	**52**
09/01/2013	1.65	0.82	**50**
16/01/2013	1.98	0.99	**50**
23/01/2013	1.62	0.81	**50**
30/01/2013	1.89	0.93	**51**
07/02/2012	1.74	0.88	**49**
14/02/2013	2.3	1.18	**49**
21/02/2013	2.4	1.42	**41**
28/02/2013	2.9	1.66	**43**
08/03/2013	3.6	1.78	**51**
15/03/2013	3.97	1.95	**51**
22/03/2013	3.59	1.77	**51**
28/03/2013	3.94	1.93	**51**
04/04/2013	3.9	1.95	**50**
11/04/2013	3.25	1.14	**65**
17/04/2013	3.65	1.24	**66**
24/04/2013	3.46	1.14	**67**
03/05/2013	3.9	1.21	**69**
09/05/2013	4.2	1.22	**71**
16/05/2013	4.1	0.80	**80**
24/05/2013	4.63	0.85	**82**
30/05/2013	4.32	0.74	**83**
03/06/2013	4.89	0.70	**86**
13/06/2013	3.2	0.36	**89**
20/06/2013	2.9	0.54	**82**
27/06/2013	3.6	0.67	**81**

04/07/2013	4.9	0.48	**90**
11/07/2013	5.1	0.50	**90**
18/07/2013	5.6	0.57	**90**
25/07/2013	5.84	0.58	**90**
01/08/2013	5.63	0.71	**87**
07/08/2013	10.56	1.03	**90**
13/08/2013	6.8	0.66	**90**
21/08/2013	7.9	0.75	**90**
28/08/2013	8.45	0.79	**91**
04/09/2013	5.53	0.53	**90**
11/09/2013	5.1	0.48	**91**
18/09/2013	4.2	0.38	**91**
25/09/2013	4.32	0.44	**90**

Table 6 The ammonium removal in the photobioreactor systems

Phosphorous

	P –PO_4 [mg/l]		P –PO_4 [%]
DATA	*inlet*	*outlet*	*removal*
04/10/2012	0.105	0.053	**50**
11/10/2012	0.141	0.072	**49**
18/10/2012	0.187	0.097	**48**
25/10/2012	0.204	0.114	**44**
08/11/2012	0.18	0.106	**41**
15/11/2012	0.17	0.102	**40**
22/11/2012	0.21	0.126	**40**
29/11/2012	0.198	0.109	**45**
05/12/2012	0.100	0.040	**60**
13/12/2012	0.132	0.059	**55**
20/12/2012	0.141	0.097	**31**
09/01/2013	0.110	0.077	**30**
16/01/2013	0.098	0.060	**39**
23/01/2013	0.097	0.059	**39**
30/01/2013	0.951	0.571	**40**
07/02/2012	0.078	0.056	**28**
14/02/2013	0.089	0.069	**22**
21/02/2013	0.098	0.070	**29**
28/02/2013	0.198	0.139	**30**
08/03/2013	0.149	0.098	**34**
15/03/2013	0.174	0.108	**38**
22/03/2013	0.188	0.115	**39**
28/03/2013	0.186	0.110	**41**
04/04/2013	0.203	0.104	**49**
11/04/2013	0.214	0.107	**50**
17/04/2013	0.216	0.106	**51**
24/04/2013	0.187	0.090	**52**
03/05/2013	0.149	0.073	**51**
09/05/2013	0.207	0.099	**52**
16/05/2013	0.231	0.113	**51**
24/05/2013	0.234	0.112	**52**
30/05/2013	0.217	0.087	**60**
03/06/2013	0.294	0.118	**60**
13/06/2013	0.198	0.079	**60**
20/06/2013	0.188	0.073	**61**
27/06/2013	0.210	0.082	**61**
04/07/2013	0.278	0.092	**67**

11/07/2013	0.296	0.092	**69**
18/07/2013	0.310	0.093	**70**
25/07/2013	0.237	0.052	**78**
01/08/2013	0.255	0.056	**78**
07/08/2013	0.354	0.074	**79**
13/08/2013	0.322	0.064	**80**
21/08/2013	0.369	0.066	**82**
28/08/2013	0.299	0.066	**78**
04/09/2013	0.289	0.072	**75**
11/09/2013	0.305	0.070	**77**
18/09/2013	0.298	0.066	**78**
25/09/2013	0.274	0.058	**79**

Table 7 The total phosphorous removal in the photobioreactor systems

Chemical Oxygen Demand (COD)

DATE	COD [mg/l] *inlet*	COD [mg/l] *outlet*	COD [%] *removal*
04/10/2012	27	20.25	25
11/10/2012	24	18.72	**22**
18/10/2012	20	16.00	**20**
25/10/2012	19	15.01	**21**
08/11/2012	15	11.70	**22**
15/11/2012	12	9.84	**18**
22/11/2012	18	15.30	**15**
29/11/2012	22	19.80	**10**
05/12/2012	23	20.84	**9.4**
13/12/2012	20	18.40	**8**
20/12/2012	16	14.64	**8.5**
09/01/2013	12	9.60	**20**
16/01/2013	15	12.15	**19**
23/01/2013	14	11.48	**18**
30/01/2013	18	14.40	**20**
07/02/2012	10	7.80	**22**
14/02/2013	9	8.10	**10**
21/02/2013	12	10.56	**12**
28/02/2013	11	12.00	**0**
08/03/2013	10	15.00	**0**
15/03/2013	12	18.00	**0**
22/03/2013	10	20.00	**0**
28/03/2013	11	19.00	**0**
04/04/2013	15	10.50	**30**
11/04/2013	18	12.42	**31**
17/04/2013	22	14.96	**32**
24/04/2013	20	14.00	**30**
03/05/2013	24	13.92	**42**
09/05/2013	26	14.30	**45**
16/05/2013	25	12.50	**50**
24/05/2013	24	11.52	**52**
30/05/2013	28	12.60	**55**
03/06/2013	30	22.50	**25**
13/06/2013	28	19.88	**29**
20/06/2013	27	18.63	**31**
27/06/2013	29	21.17	**27**

04/07/2013	31	16.43	**47**
11/07/2013	35	20.65	**41**
18/07/2013	30	15.00	**50**
25/07/2013	29	14.21	**51**
01/08/2013	30	14.40	**52**
07/08/2013	32	15.04	**53**
13/08/2013	30	12.30	**59**
21/08/2013	31	15.50	**50**
28/08/2013	29	14.79	**49**
04/09/2013	30	15.00	**50**
11/09/2013	33	17.16	**48**
18/09/2013	32	16.96	**47**
25/09/2013	30	16.80	**44**

***Table 8** The COD removal in the photobioreactor systems*

The average values for the four seasons

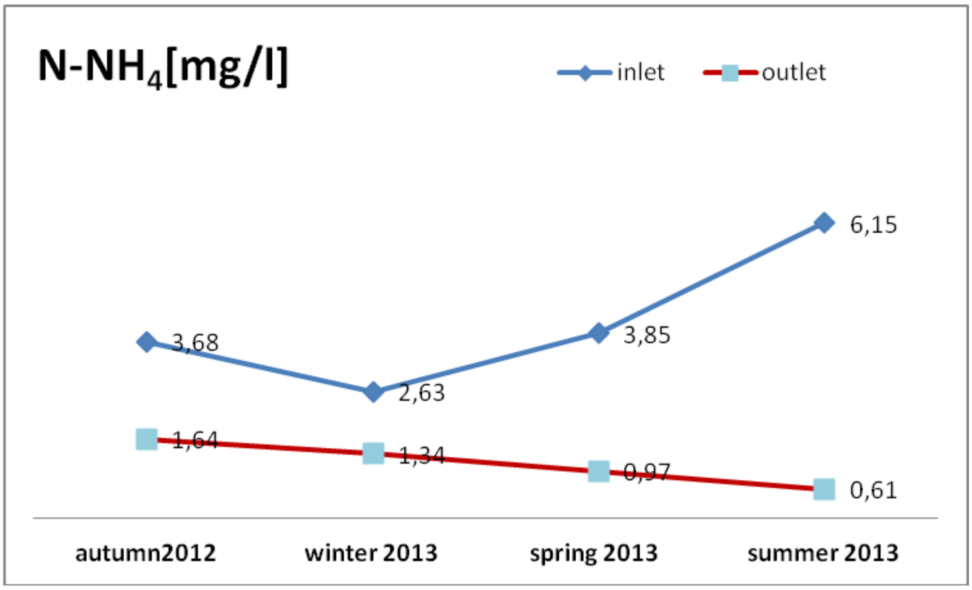

Figure 1 *The average values of ammonium in the photobioreactor system for the 4 seasons*

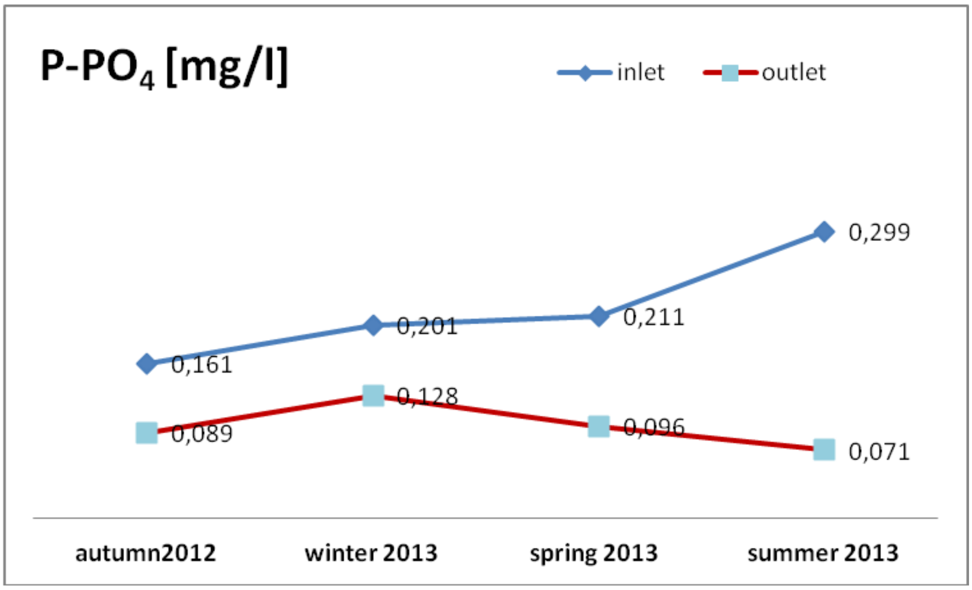

***Figure* 2** *The average values of phosphorous in the photobioreactor system for the 4 seasons*

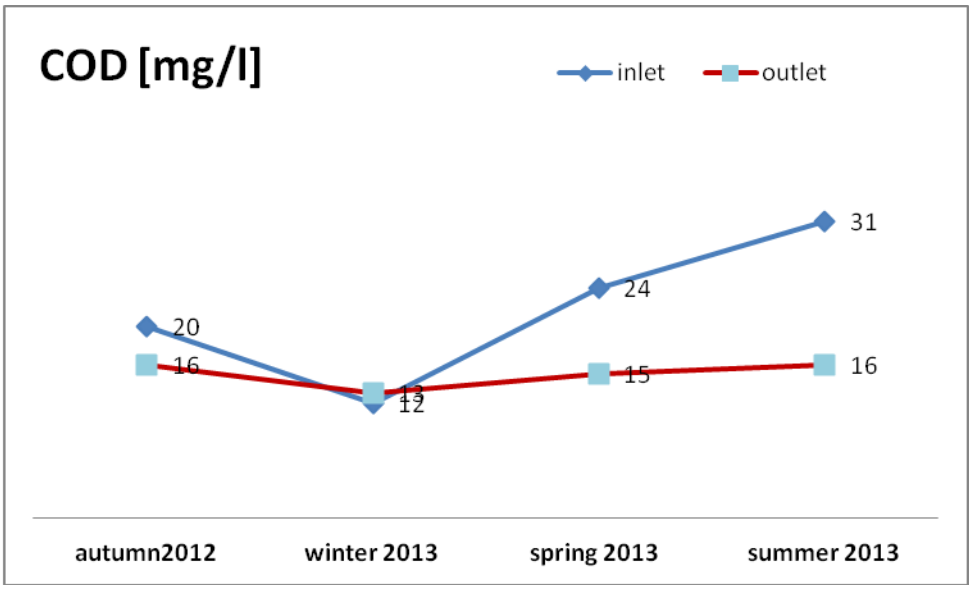

***Figure* 3** *The average values of COD in the photobioreactor system for the 4 seasons*

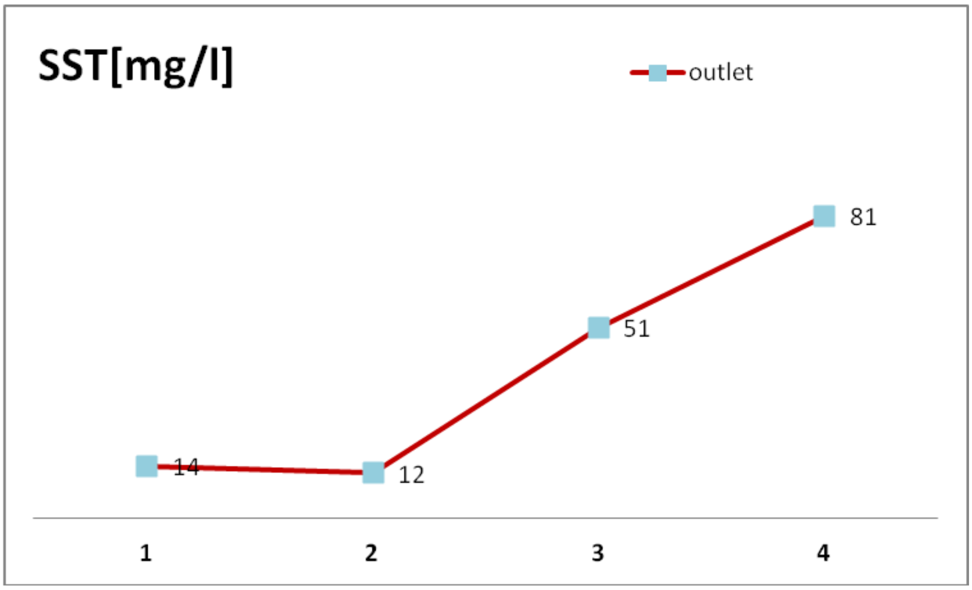

Figure 4 *The average values of outlet SST from the photobioreactor system for the 4 seasons*

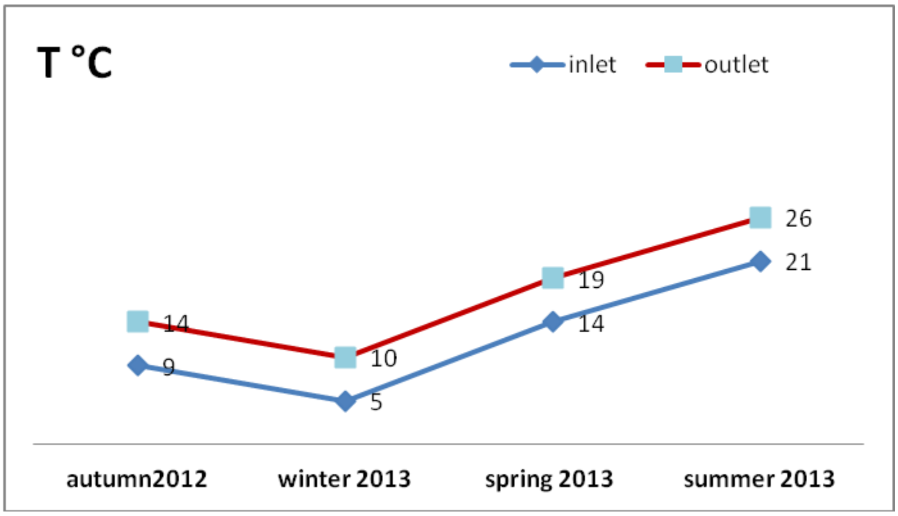

Figure 5 *The average values of temperature in the Photobioreactor system for the 4 seasons*

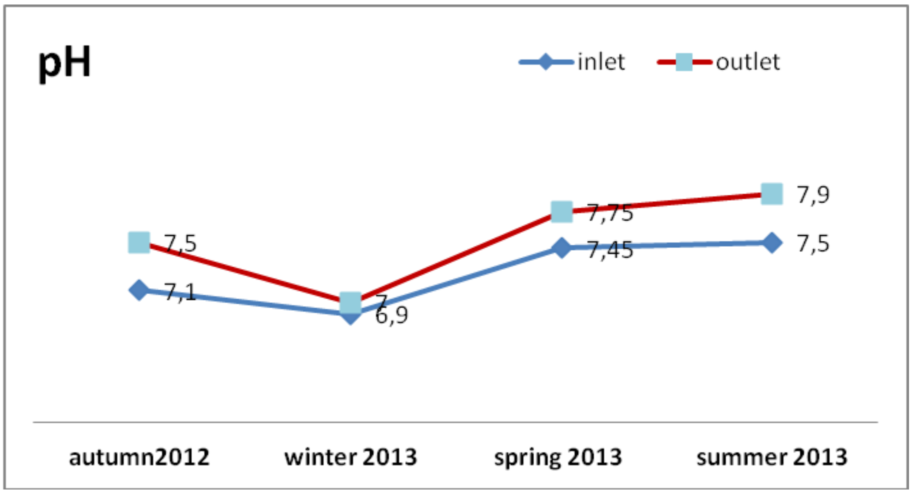

Figure 6 *The average values of pH in the photobioreactor system for the 4 seasons*

The results about temperature of photobioreactor system show as during the four seasons the average values are maintained always in the good range to grow to algal biomass.

The Algal biomass values for the four seasons

			average values	*average values*
DATA	algal biomass mg/l	chlorophyll a mg/l	algal biomass mg/l	chlorophyll a mg/l
25/10/2012	26.00	0.10		
29/11/2012	15.00	0.07		
20/12/2012	18.00	0.05	19.67	0.07
23/01/2013	15.00	0.03		
14/02/2013	15.00	0.02		
08/03/2013	10.00	0.03		
28/03/2013	19.00	0.05	14.75	0.03
24/04/2013	50.00	1.50		
24/05/2013	75.00	1.90		
20/06/2013	80.00	2.10	68.33	1.83
18/07/2013	110.00	4.50		
13/08/2013	109.00	4.20		
04/09/2013	98.00	3.90	105.67	4.20

Table 9 *Chlorophyll a and algal biomass concentration for the photobioeactor system*

The determination of carbon dioxide CO_2

DATA	CO_2 [% volume]
18/04/2012	0.90
27/04/2012	1.10
04/05/2012	1.10
11/05/2012	1.20
16/05/2012	1.20
24/05/2012	1.30
20/06/2012	1.40
27/06/2012	1.40
12/07/2012	1.70
18/07/2012	1.80
26/07/2012	2.00
01/08/2012	1.70
08/08/2012	1.60
22/08/2012	1.50
25/09/2012	1.50
11/10/2012	1.50
18/10/2012	1.10
25/10/2012	1.00
15/11/2012	1.20
22/11/2012	1.60
29/11/2012	2.00
13/12/2012	1.40
20/12/2012	1.50
23/01/2013	1.00
30/01/2013	1.20
14/02/2013	1.00
21/02/2013	1.30
08/03/2013	2.00
15/03/2013	1.50
28/03/2013	1.00
24/04/2013	2.00
24/05/2013	1.90
20/06/2013	2.10
18/07/2013	2.10
13/08/2013	1.90
04/09/2013	1.70

Table 10 *The CO_2 concentration (% of volume) in the gaseous emission from biological oxidation tank of S. Pietro Vara plant*

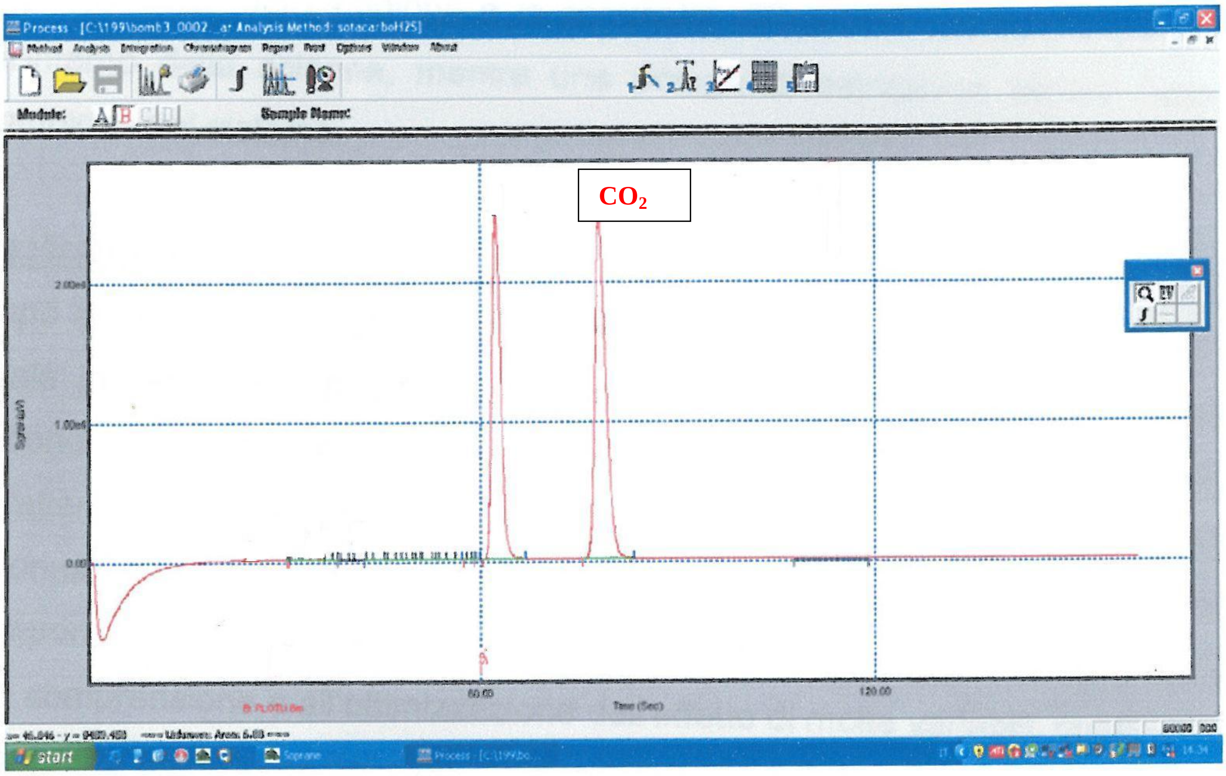

Figure 7 *The chromatographic of analysis of gas using the chromatograph equipped with TCD detector, column Poraplot U*

"LE PEZZE" OPEN MICROALGAE SYSTEM

The open microalgae system (pond) treats water coming from the farmhouse of Le Pezze (10 IE) pre-treated by a grease and oil interceptor tank and by an Imhoff tank. The results reported below refer to the pond described in detail in Deliverable 5.
From the results obtained and reported in detail in the tables and graphs below, one can draw the following conclusions related to the performance indices:

The nutrient and organic pollution removal was influenced only by seasonal factors. The tables 5-6-7 lists all values obtained during the monitoring period. For the whole period the range of removal efficiency was: N-NH_4: 6- 65%; P- PO_4: 1-84 %; COD: 21- 70%.

The algal growth: in this case there was no lack of nutrients and algal growth was limited, as expected, only by the weather conditions. The biomass produced is a bacteria algal biomass with good settleability.

The discharge rules established by Italian and Regional Laws: the effluent from the plant always meet the limits established by Italian and Regional Laws: in the case of scattered houses the Italian law (D. Lgs 152/06) requires the installation of devices like Imhoff tanks able to ensure a removal of at least 30% of the nutrients and organic load incoming.

The flexibility against nutrients and organic load variations: the system has shown great flexibility with respect to changes in nutrient loading and organic loading mainly due to two reasons: the first one the recycling of the effluent through the recirculation pump powered by solar panels (about 5 times the incoming flow); the second by the simultaneous action of bacteria present in significant amounts in the biomass.

The simplicity of management and maintenance: the system does not require any special care for its maintenance: the only operations to be done are emptying at an annual rate of mud deposited in the tanks and routine maintenance of the recycling system.

The results of pond system

In these tables the nitrogen has been reported only as ammonium because the values of nitrous and nitrate nitrogen were very low and negligible.

Pond								
season	**autumn 2012**		**winter 2013**		**spring 2013**		**summer2013**	
time	**oct-nov-dic**		**jenu-feb-mar**		**apr-may-jun**		**jul-agu-sept**	
n°sample	**10**		**11**		**12**		**12**	
	inlet	***outlet***	***inlet***	***outlet***	***inlet***	***outlet***	***inlet***	***outlet***
pH	7.04	7.3	7.1	7.0	7.0	7.0	7.1	7.1
T [C°]	9	10	5	6	15	16	20	22
N- NH4 [mg/l]	46	30	36	28	52	28	66	37
P -PO4 [mg/l]	4	2	2	1	4	2	6	1
COD [mg/l]	146	77	121	82	171	73	193	69
SST [mg/l]	-	64	-	59	-	109	-	111

Table 1 *The average values of the pond system for the 4 seasons*

N- NH4 [mg/l] inlet		**N- NH4 [mg/l] outlet**		**autumn**
minimum	**maximum**	**minimum**	**maximum**	
29.95	**70.67**	**18.80**	**40.12**	
N- NH4 [mg/l] inlet		**N- NH4 [mg/l] outlet**		**winter**
minimum	**maximum**	**minimum**	**maximum**	
20.85	**72.11**	**15.41**	**62.49**	
N- NH4 [mg/l] inlet		**N- NH4 [mg/l] outlet**		**spring**
minimum	**maximum**	**minimum**	**maximum**	
42.24	**77.75**	**15.80**	**55.14**	
N- NH4 [mg/l] inlet		**N- NH4 [mg/l] outlet**		**summer**
minimum	**maximum**	**minimum**	**maximum**	
38.61	**92.10**	**18.11**	**54.63**	

Table 2 Range of N-NH_4 concentrations at the inlet and outlet from the pond in the four seasons

P -PO4[mg/l] inlet		P -PO4[mg/l] outlet		autumn
minimum	maximum	minimum	maximum	
1.63	6.65	1.26	2.99	
P -PO4 [mg/l] inlet		**P -PO4 [mg/l] outlet**		**winter**
minimum	maximum	minimum	maximum	
1.01	2.54	0.88	1.98	
P -PO4 [mg/l] inlet		**P -PO4 [mg/l] outlet**		**spring**
minimum	maximum	minimum	maximum	
2.22	6.87	1.23	1.92	
P -PO4[mg/l] inlet		**P -PO4[mg/l] outlet**		**summer**
minimum	maximum	minimum	maximum	
5.29	6.90	0.96	1.45	

Table 3 Range of $P\text{-}PO_4$ concentrations at the inlet and outlet from the pond in the four seasons

COD [mg/l] inlet		COD [mg/l] outlet		autumn
minimum 123.50	maximum 180.70	minimum 52.77	maximum 96.82	
COD [mg/l] inlet		COD [mg/l] outlet		winter
minimum 109.20	maximum 132.60	minimum 53.82	maximum 100.78	
COD [mg/l] inlet		COD [mg/l] outlet		spring
minimum 127.40	maximum 214.50	minimum 56.06	maximum 98.74	
COD [mg/l] inlet		COD [mg/l] outlet		summer
minimum 178.10	maximum 201.50	minimum 57.72	maximum 79.99	

Table 4 *Range of COD* concentrations at the inlet and outlet from the pond in the four seasons

Nitrogen as ammonium

DATE	inlet	outlet	N- NH4 [%] removal
04/10/2012	62.95	25.18	**60**
11/10/2012	42.04	18.92	**55**
18/10/2012	70.67	38.20	**46**
25/10/2012	58.29	39.63	**32**
08/11/2012	29.95	18.80	**37**
15/11/2012	47.25	25.03	**47**
22/11/2012	32.16	24.15	**25**
29/11/2012	39.53	20.10	**49**
05/12/2012	41.63	38.44	**8**
13/12/2012	42.84	40.12	**6**
20/12/2012	43.82	39.16	**11**
09/01/2013	41.65	38.15	**8**
16/01/2013	43.17	38.94	**10**
23/01/2013	38.92	36.23	**7**
30/01/2013	72.11	62.49	**13**
07/02/2012	32.94	29.18	**11**
14/02/2013	21.20	19.56	**8**
21/02/2013	20.85	18.88	**9**
28/02/2013	27.30	19.95	**27**
08/03/2013	25.16	21.41	**15**
15/03/2013	22.33	15.41	**31**
22/03/2013	38.79	18.32	**53**
28/03/2013	42.94	19.13	**55**
04/04/2013	45.26	21.12	**53**
11/04/2013	44.67	25.14	**44**
17/04/2013	45.81	20.15	**56**
24/04/2013	58.29	25.56	**56**
03/05/2013	51.40	28.45	**45**
09/05/2013	51.32	27.05	**47**
16/05/2013	42.86	18.75	**56**
24/05/2013	42.47	15.80	**63**
30/05/2013	42.53	17.13	**60**
03/06/2013	42.24	21.65	**49**
13/06/2013	70.82	38.20	**46**
20/06/2013	62.35	55.14	**12**
27/06/2013	77.75	49.27	**37**
04/07/2013	60.90	33.48	**45**
11/07/2013	64.76	41.05	**37**

18/07/2013	63.32	38.65	**39**
25/07/2013	46.90	35.60	**24**
01/08/2013	80.40	48.24	**40**
07/08/2013	86.29	50.02	**42**
13/08/2013	90.40	48.32	**47**
21/08/2013	81.50	39.27	**52**
28/08/2013	92.10	54.63	**41**
04/09/2013	57.53	31.78	**45**
11/09/2013	41.73	20.35	**51**
18/09/2013	38.61	18.11	**53**
25/09/2013	55.24	19.60	**65**

***Table 5** The ammonium removal in the pond systems*

Phosphorous

DATE	inlet	outlet	P -PO4 [%] removal
04/10/2012	6.65	2.99	**55**
11/10/2012	6.36	2.86	**55**
18/10/2012	5.68	2.33	**59**
25/10/2012	4.05	1.62	**60**
08/11/2012	3.51	1.72	**51**
15/11/2012	2.54	1.32	**48**
22/11/2012	2.68	1.58	**41**
29/11/2012	1.94	1.26	**35**
05/12/2012	2.09	1.40	**33**
13/12/2012	1.63	1.27	**22**
20/12/2012	2.25	1.82	**19**
09/01/2013	1.57	1.33	**15**
16/01/2013	1.94	1.72	**11**
23/01/2013	1.25	1.19	**5**
30/01/2013	1.41	1.40	**1**
07/02/2012	1.01	0.88	**12**
14/02/2013	1.24	1.06	**14**
21/02/2013	1.50	1.33	**11**
28/02/2013	1.56	1.33	**15**
08/03/2013	1.83	1.67	**9**
15/03/2013	2.11	1.85	**12**
22/03/2013	2.54	1.98	**22**
28/03/2013	1.40	1.12	**20**
04/04/2013	2.22	1.53	**31**
11/04/2013	2.55	1.66	**35**
17/04/2013	2.67	1.89	**29**
24/04/2013	2.47	1.43	**42**
03/05/2013	2.87	1.58	**45**
09/05/2013	3.35	1.88	**44**
16/05/2013	3.07	1.23	**60**
24/05/2013	3.46	1.66	**52**
30/05/2013	3.51	1.37	**61**
03/06/2013	4.03	1.33	**67**
13/06/2013	5.15	1.80	**65**
20/06/2013	5.50	1.59	**71**
27/06/2013	6.87	1.92	**72**
04/07/2013	5.67	1.25	**78**
11/07/2013	6.05	1.45	**76**

18/07/2013	6.04	1.39	**77**
25/07/2013	5.29	1.01	**81**
01/08/2013	6.90	1.38	**80**
07/08/2013	6.81	1.22	**82**
13/08/2013	5.29	1.01	**81**
21/08/2013	6.27	1.32	**79**
28/08/2013	6.00	0.96	**84**
04/09/2013	5.68	1.25	**78**
11/09/2013	6.21	1.43	**77**
18/09/2013	6.13	1.35	**78**
25/09/2013	6.13	1.16	**81**

Table 6 *The total phosphorous removal in the pond systems*

Chemical Oxygen Demand (COD)

DATA	*inlet*	*outlet*	COD [%] *removal*
04/10/2012	180.70	86.74	**52**
11/10/2012	146.25	80.44	**45**
18/10/2012	174.85	73.44	**58**
25/10/2012	159.25	63.70	**60**
08/11/2012	153.40	70.56	**54**
15/11/2012	128.70	52.77	**59**
22/11/2012	143.00	74.36	**48**
29/11/2012	139.10	73.72	**47**
05/12/2012	127.40	96.82	**24**
13/12/2012	124.80	88.61	**29**
20/12/2012	123.50	90.16	**27**
09/01/2013	116.35	91.92	**21**
16/01/2013	124.15	96.84	**22**
23/01/2013	121.55	96.02	**21**
30/01/2013	125.45	96.60	**23**
07/02/2012	132.60	100.78	**24**
14/02/2013	128.70	83.66	**35**
21/02/2013	127.40	76.44	**40**
28/02/2013	113.75	70.53	**38**
08/03/2013	115.05	72.48	**37**
15/03/2013	109.20	73.16	**33**
22/03/2013	116.35	75.63	**35**
28/03/2013	119.60	53.82	**55**
04/04/2013	127.40	56.06	**56**
11/04/2013	130.65	56.18	**57**
17/04/2013	135.85	61.13	**55**
24/04/2013	153.40	62.89	**59**
03/05/2013	157.95	63.18	**60**
09/05/2013	160.55	73.85	**54**
16/05/2013	168.35	79.12	**53**
24/05/2013	182.00	83.72	**54**
30/05/2013	201.50	98.74	**51**
03/06/2013	208.65	87.63	**58**
13/06/2013	214.50	83.66	**61**
20/06/2013	193.70	71.67	**63**
27/06/2013	193.05	75.29	**61**
04/07/2013	197.60	71.14	**64**
11/07/2013	193.05	67.57	**65**

18/07/2013	186.55	72.75	**61**
25/07/2013	178.10	73.02	**59**
01/08/2013	190.45	79.99	**58**
07/08/2013	193.05	75.29	**61**
13/08/2013	191.75	72.87	**62**
21/08/2013	199.55	73.83	**63**
28/08/2013	198.90	73.59	**63**
04/09/2013	201.50	60.45	**70**
11/09/2013	191.10	59.24	**69**
18/09/2013	192.40	57.72	**70**
25/09/2013	193.70	61.98	**68**

Table 7 *The COD removal in the pond systems*

The average values for the four seasons

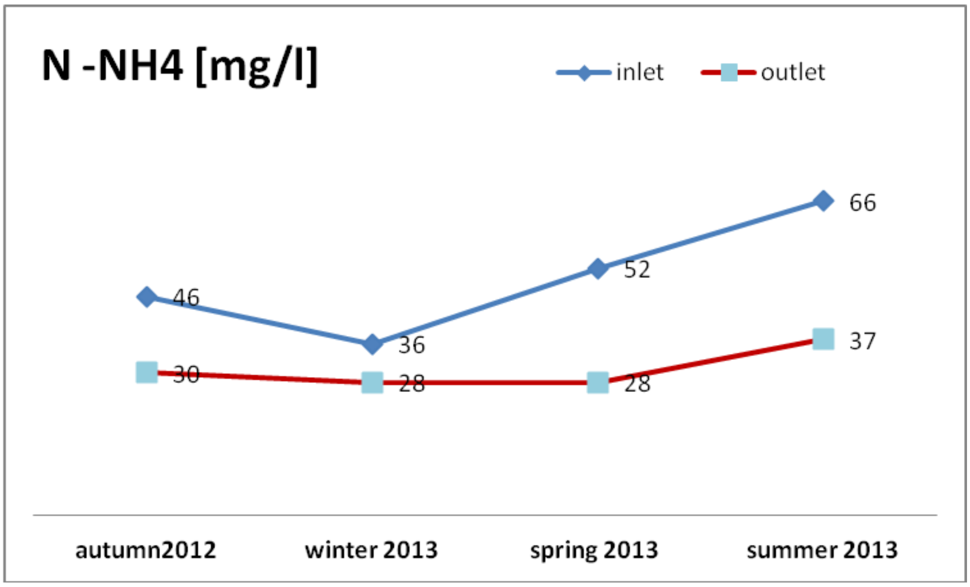

Figure 1 *The average values of ammonium in the pond system for the 4 seasons*

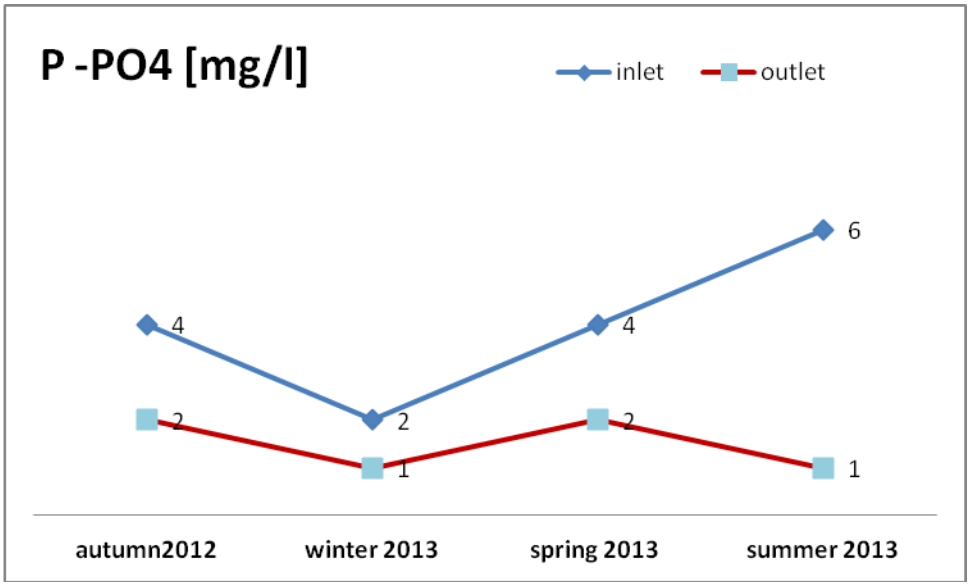

***Figure 2** The average values of phosphorous in the pond system for the 4 seasons*

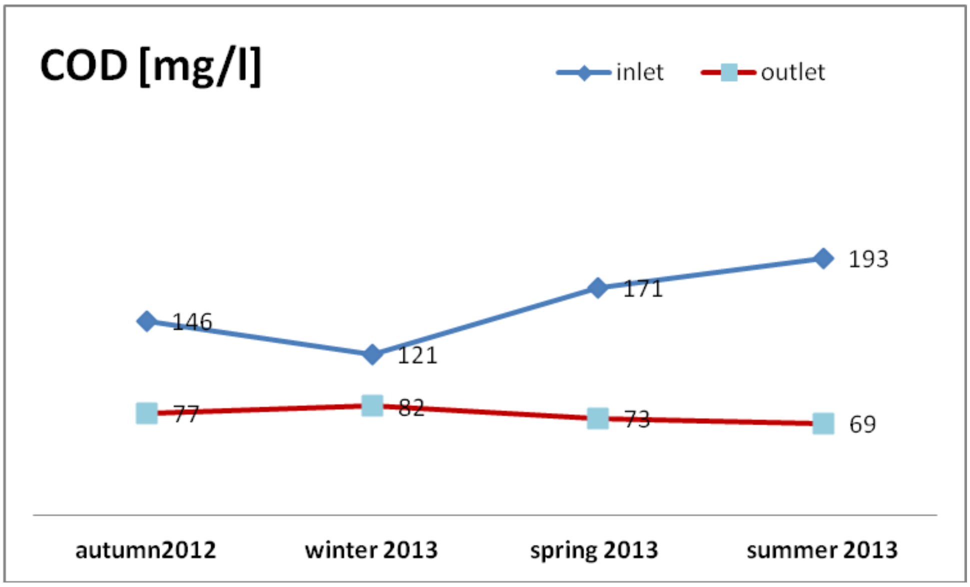

***Figure 3** The average values of COD in the pond system for the 4 seasons*

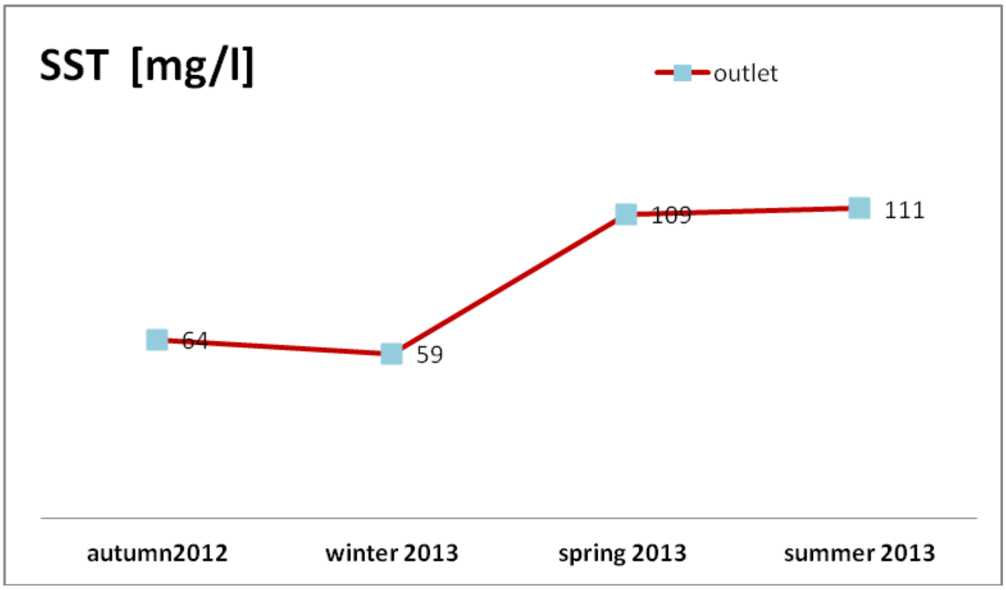

Figure 4 *The average values of outlet SST from the pond system for the 4 seasons*

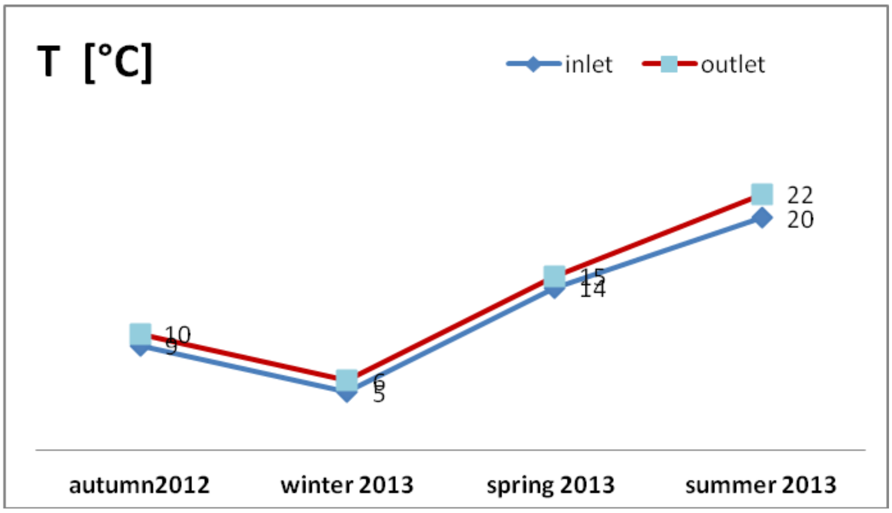

Figure 5 *The average values of temperature in the pond system for the 4 seasons*

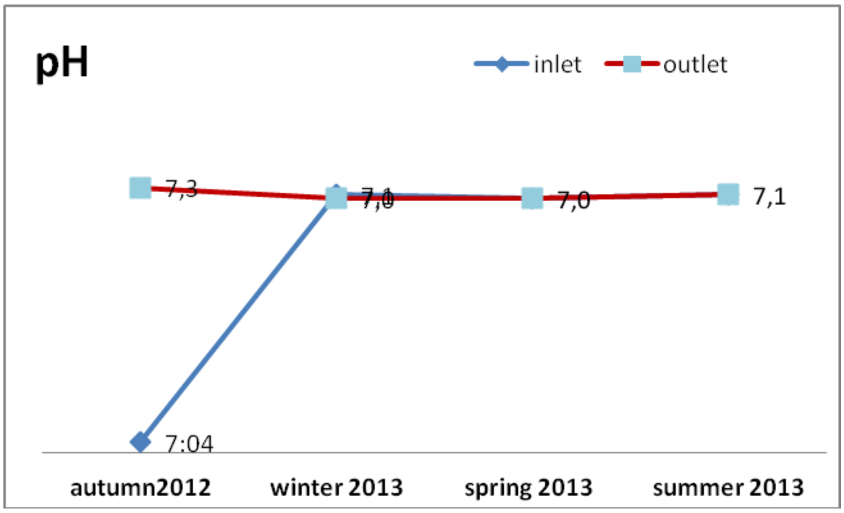

Figure 6 *The average values of pH in the pond system for the 4 seasons*

The Algal biomass values for the four seasons

			average values	*average values*
DATE	algal biomass mg/l	chlorophyll a mg/l	algal biomass mg/l	chlorophyll a mg/l
25/10/2012	98.00	4.90		
29/11/2012	62.00	2.60		
20/12/2012	54.00	1.90	71.33	3.13
23/01/2013	51.00	1.80		
14/02/2013	62.00	2.10		
08/03/2013	75.00	1.98		
28/03/2013	81.00	2.43	67.25	2.08
24/04/2013	256.00	13.50		
24/05/2013	362.00	22.60		
20/06/2013	475.00	28.50	364.33	21.53
18/07/2013	510.00	45.90		
13/08/2013	505.00	30.23		
04/09/2013	498.00	27.36	504.33	34.50

***Table 8** Chlorophyll a and algal biomass concentration for the pond system*

STORMWATER RUNOFF

MUNICIPAL WASTE DEPOT

Data collected

The monitoring campaign carried out at Municipal Waste Depot pilot site provides the assessment of pollutant load discharged by storm runoff in drainage system equipped with on-line first flush tank. By comparing the pollutant load associated with untreated storm runoff (VARESE IN gauge station) and the one associated with treated storm runoff (VARESE OUT gauge station), the treatment efficiency of the installed traditional treatment system (on-line tank) has been evaluated. Such analysis has been performed both at the scale of the whole monitoring campaign and at the event scale.

In order to correctly analyse data collected through VARESE IN and VARESE OUT gauge stations, rainfall-runoff events have to be validated. Firstly, quantity data have been examined in terms of data acquisition, rainfall-runoff processes and stage-discharge curve (level translated to flow-rate). Secondly the sampling program has been validated, particularly, taking into account the sampling time distribution across the hydrograph to accurately represent pollutant delivery behaviour.
Note that the monitoring campaign carried out at Municipal Waste Depot pilot site has been interrupted in some periods due both to technical problems or severe climatic conditions (heavy snowfalls) as illustrated in the deliverable D5 “Technical Report on the collected data during the monitoring campaign”. In spite of this 19 rainfall-runoff events have been collected for the period from December 2011 to November 2012 and the corresponding available quality-quantity data provided enough information to characterise the quality of both untreated and treated storm water runoff, thus the monitoring campaign achieved the expected results and it can be considered comprehensive.

Water quality data – Acute values

In order to illustrate the observed variability of the pollutant load associated with storm water runoff, this section illustrate the single concentration values observed across the whole monitoring programme. Such analysis has two main purposes: at first taking into account that water quality standards are based on concentration values, it aims at pointing out the exceeding of quality standard on sample basis, secondly it aims at comparing the temporal variation of the pollutant load across the single hydrograph with respect to than the one observed across the whole monitoring programme. Furthermore by comparing the pollutant load associated to both untreated and treated storm water runoff, the analysis of the pollutant delivery behaviour based on sample basis allows to point out if the adopted treatment system is effective in reducing the acute values observed in storm water runoff at the inlet section of the system.

Figure 1 illustrates the concentration values observed across the whole monitoring programme with respect to all investigated parameters, while the concentration values observed for each rainfall-runoff event with respect to each investigated parameter are illustrated in Figure 2 to Figure 7. In particular, water quality data are presented as box plots representing statistical results on a sample basis. The lower and upper boundary of each box indicate respectively the 25th and 75th percentiles, while the thin and thick lines within the box mark the median and mean values respectively. Whiskers above and below each box indicate the 90th and 10th percentiles; individual crosses showed in the plot represent the 5th and 95th percentiles. In each figure the grey filled boxes refer to the pollutant concentration values observed in the untreated storm water runoff (before entering into the on-line tank), while the hatched filled boxes refer to the pollutant concentration values observed in the treated storm water runoff (at the outlet section of the on-line tank).

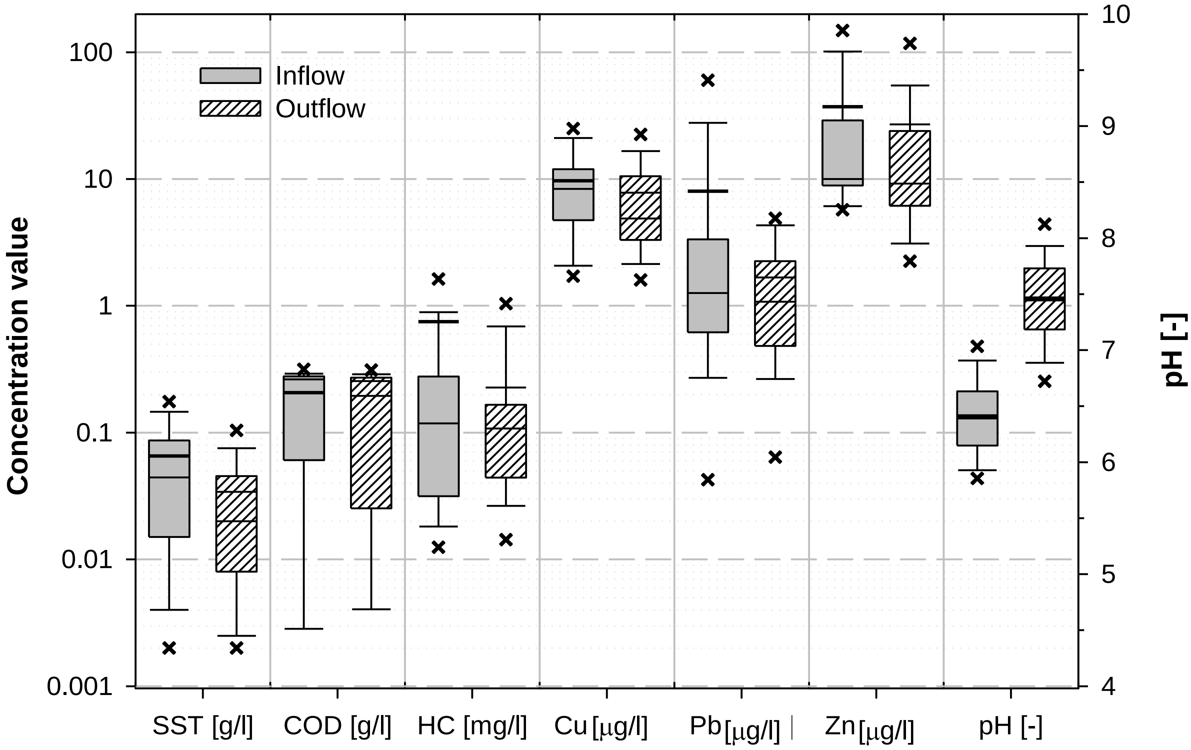

Figure 1 Non-parametric distribution of concentration values for water quality constituents observed in the storm water runoff before (inflow) and after (outflow) the treatment system at the Municipal waste depot.

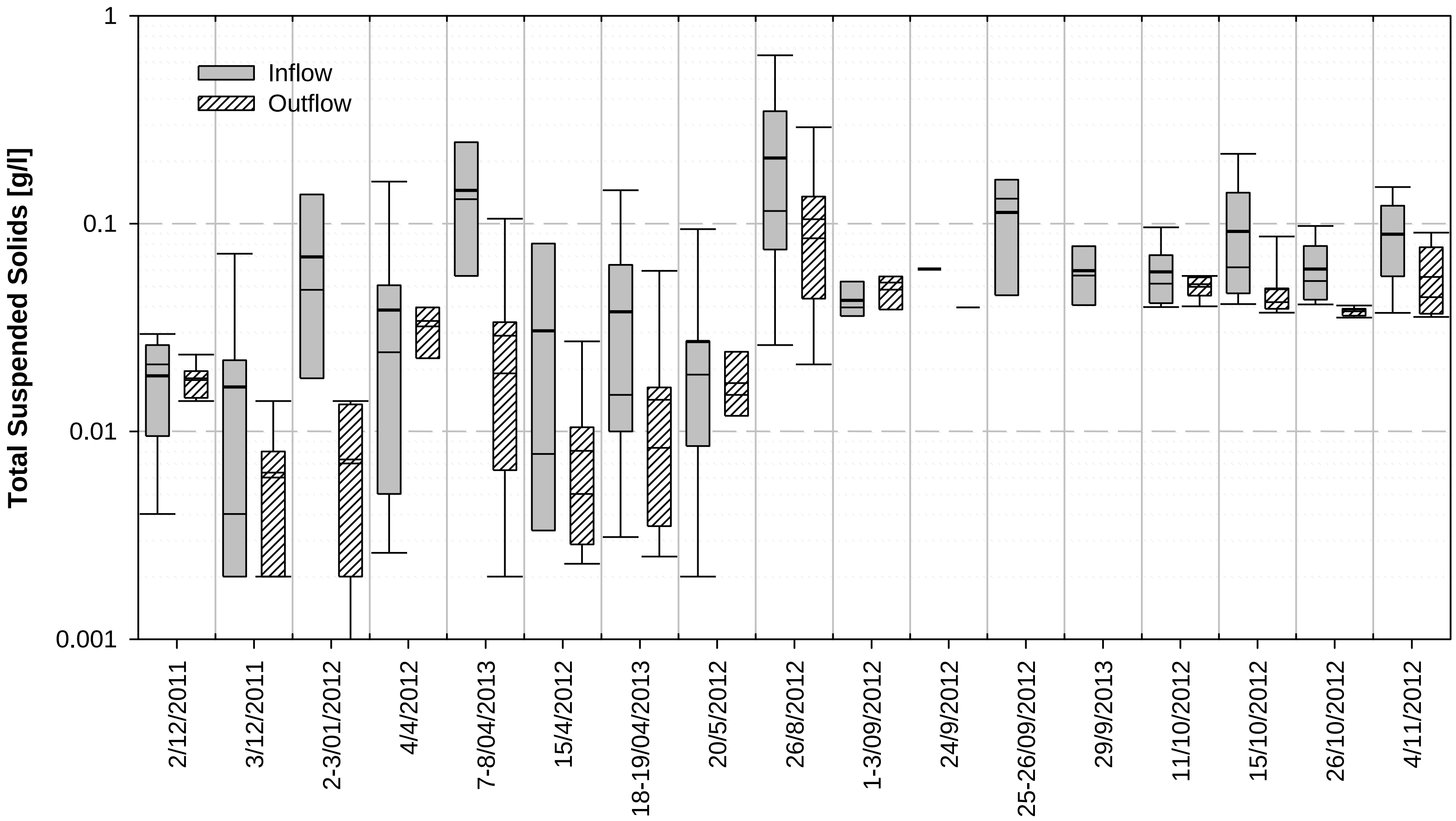

Figure 2 Non-parametric distribution of concentration values for TSS for each rainfall event observed in the storm water runoff before (inflow) and after (outflow) the treatment system at the Municipal waste depot.

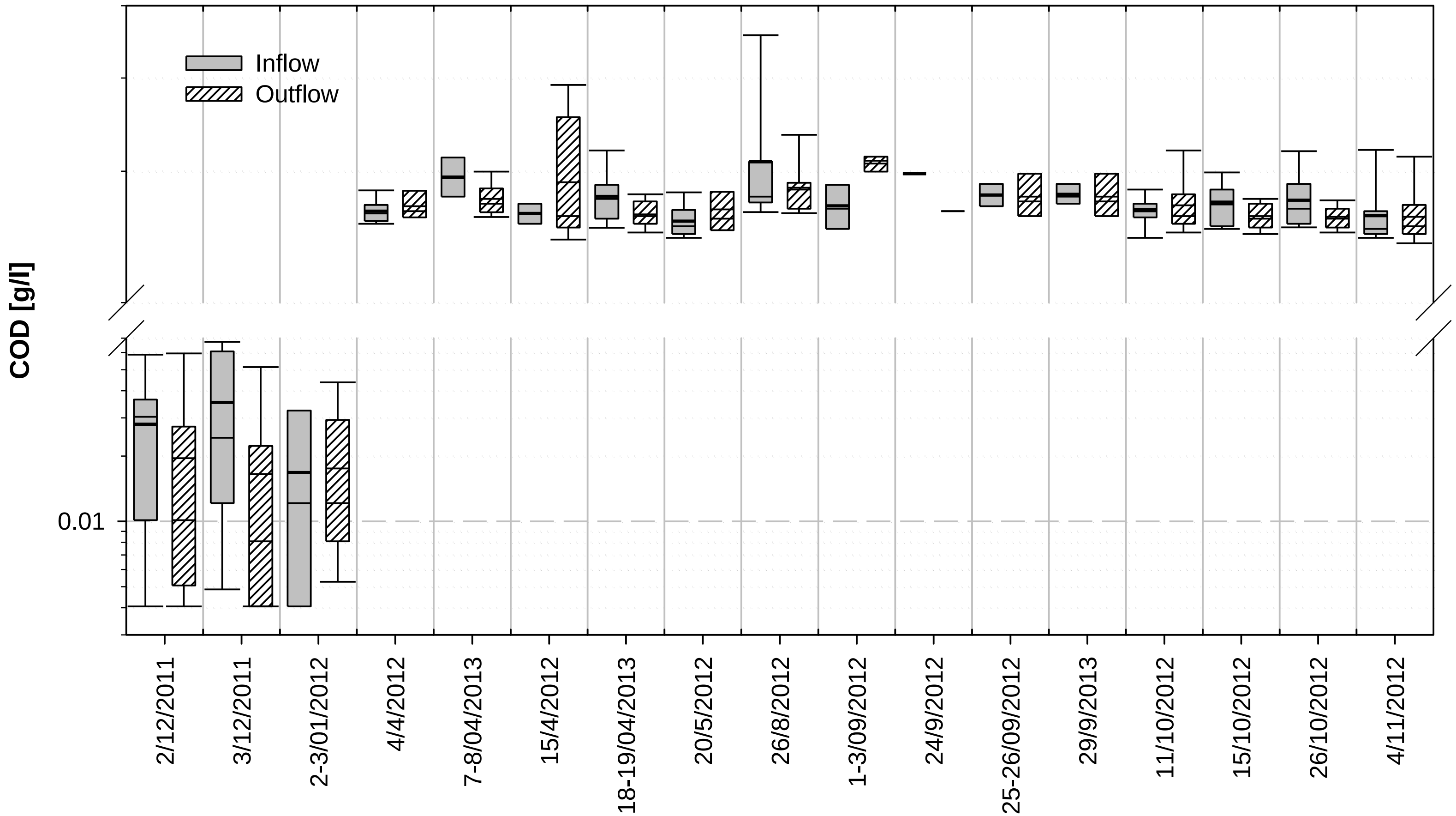

Figure 3 Non-parametric distribution of concentration values for COD for each rainfall event observed in the storm water runoff before (inflow) and after (outflow) the treatment system at the Municipal waste depot.

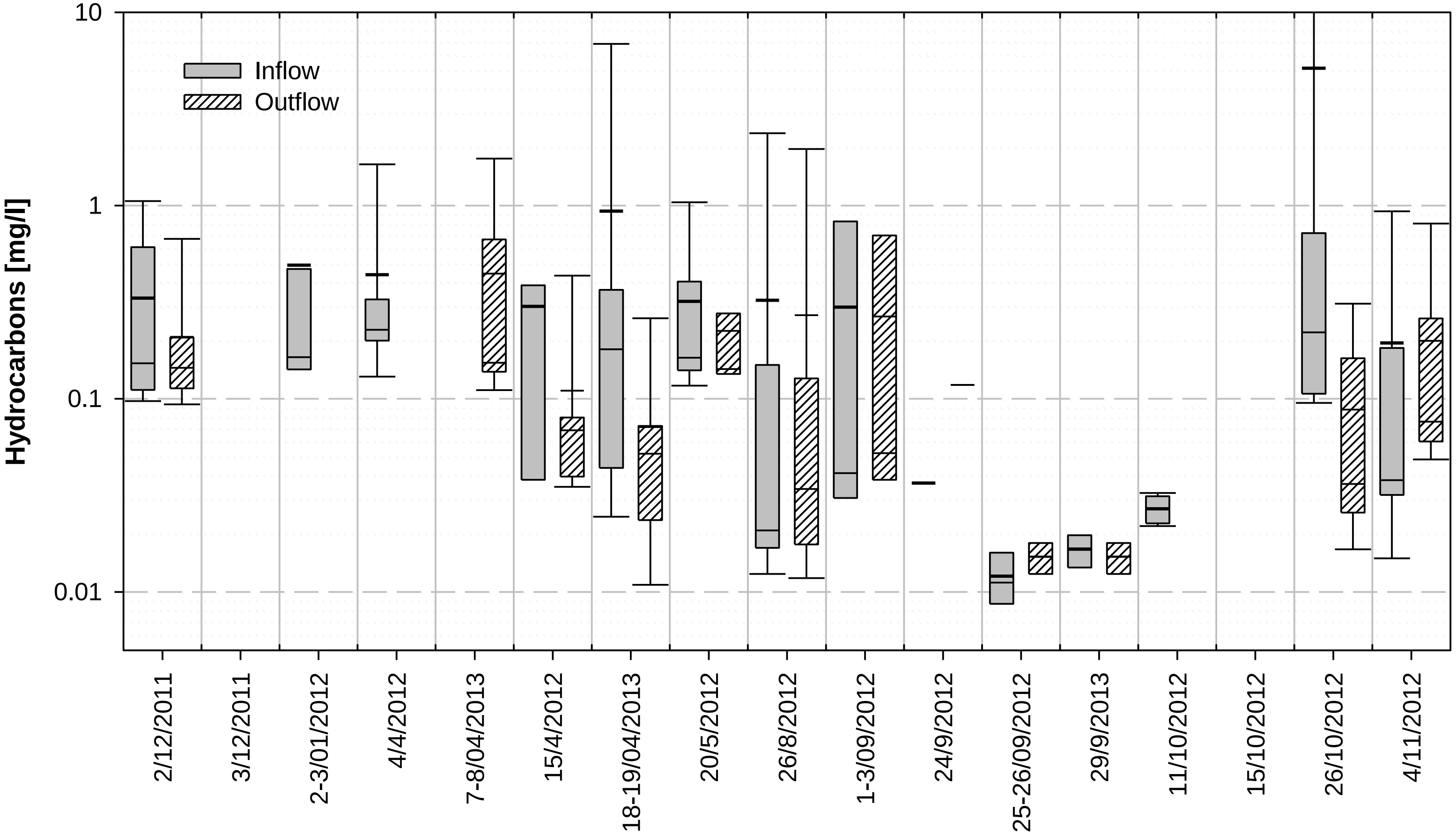

Figure 4 Non-parametric distribution of concentration values for HC for each rainfall event observed in the storm water runoff before (inflow) and after (outflow) the treatment system at the Municipal waste depot.

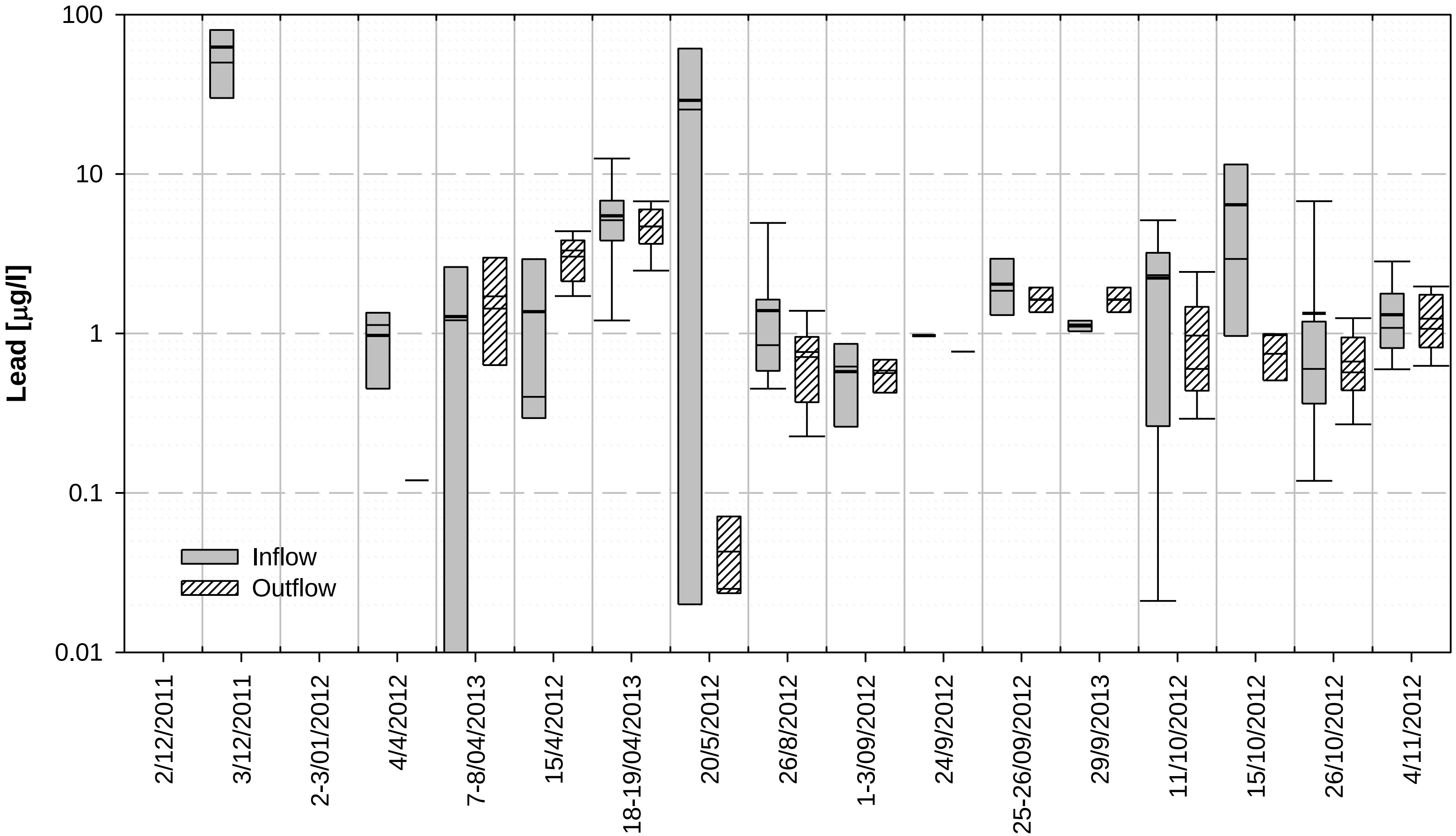

Figure 5 Non-parametric distribution of concentration values for Pb for each rainfall event observed in the storm water runoff before (inflow) and after (outflow) the treatment system at the Municipal waste depot.

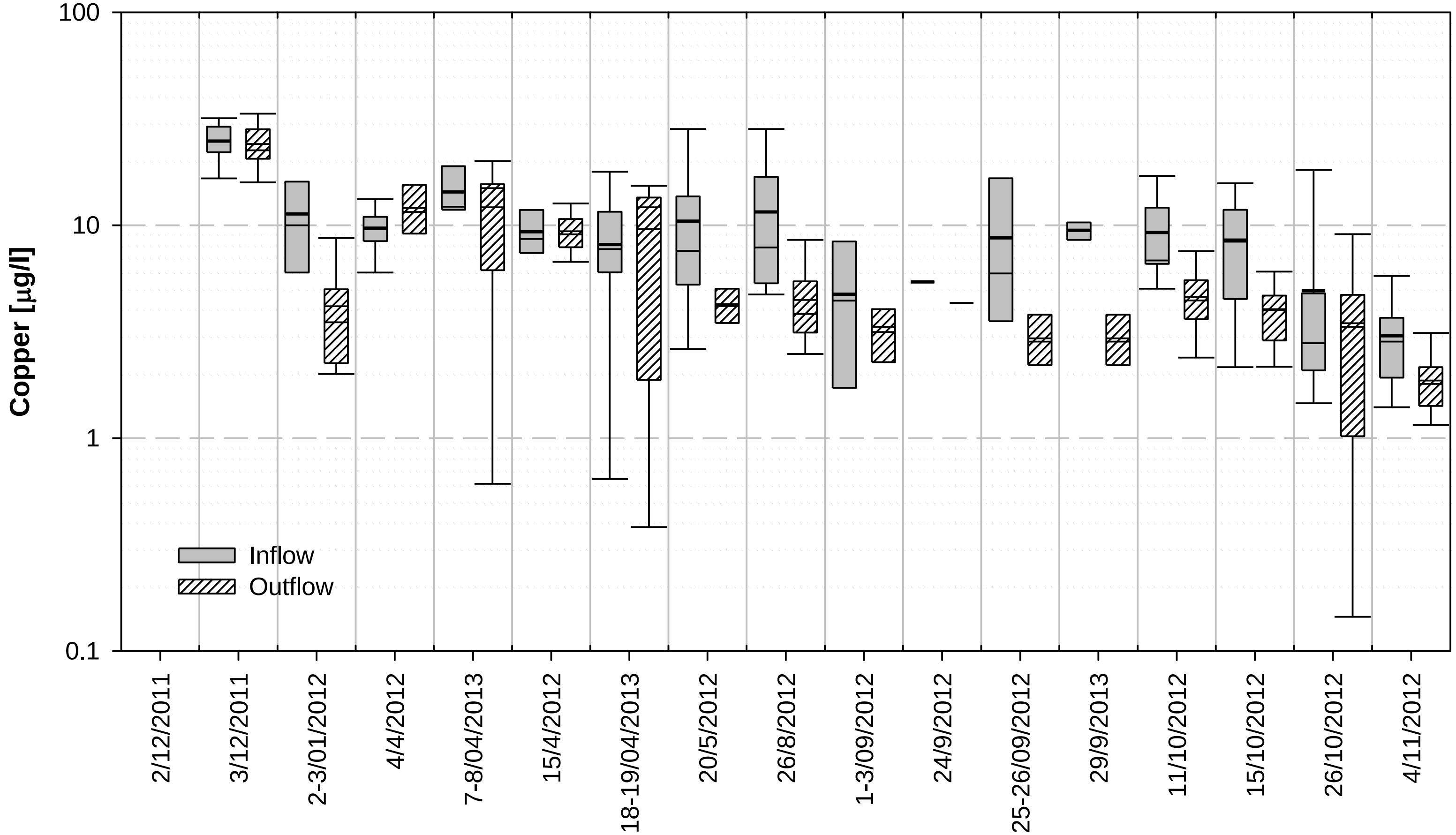

Figure 6 Non-parametric distribution of concentration values for Cu for each rainfall event observed in the storm water runoff before (inflow) and after (outflow) the treatment system at the Municipal waste depot.

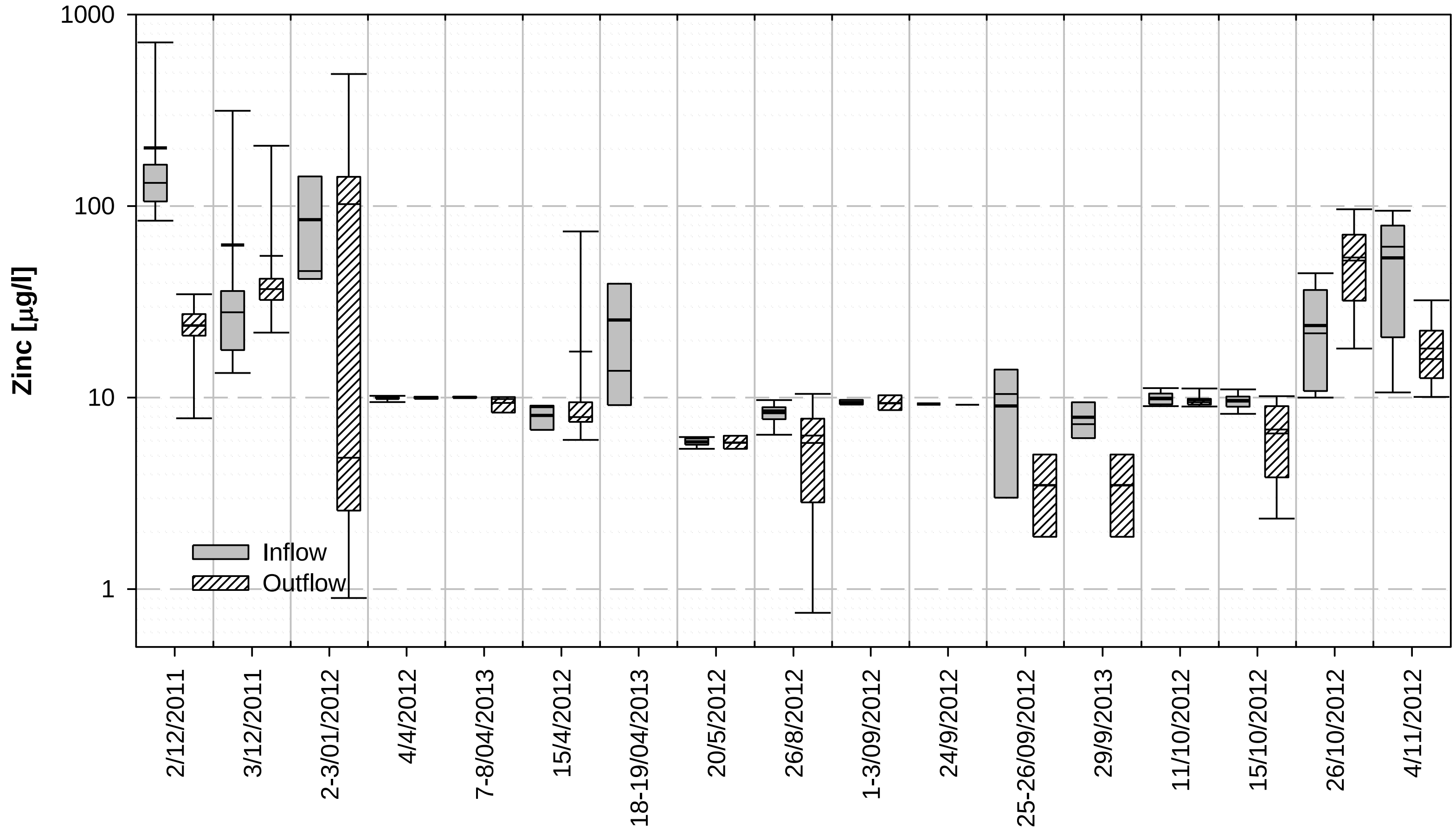

Figure 7 Non-parametric distribution of concentration values for Zn for each rainfall event observed in the storm water runoff before (inflow) and after (outflow) the treatment system at the Municipal waste depot.

Water quality data – Mean values

Due to the significant temporal variation of the pollutant concentration and flow rate across any rainfall-runoff event, the event mean concentration (EMC), which constitutes an event scale parameter, provides a significant assessment of the pollutant load associate with each rainfall-runoff thus allowing to compare results across the whole monitoring campaign. The Event Mean Concentration (EMC – flow-weighted average of constituent concentrations) is determined trough the following expression:

$$EMC = \frac{M}{V} = \overline{C} = \frac{\int_0^T c(t)q(t)dt}{\int_0^T q(t)dt}$$

where *c(t)* and *q(t)* represent respectively the pollutograph and the hydrograph of each monitored rainfall-runoff event and *T* corresponds to the event duration.

In Table 1 and Table 2 the event mean concentrations, the maximum and minimum concentrations for each rainfall-runoff event monitored at VARESE IN pilot site (untreated stormwater runoff) are summarised with respect to the analysed parameters (general water quality constituents, hydrocarbons and heavy metals); furthermore the range of the EMC, in terms of mean value and standard deviation, across the whole monitoring campaign is reported.

In Table 3 and Table 4 the event mean concentrations, the maximum and minimum concentrations for each rainfall-runoff event monitored at VARESE OUT pilot site (treated stormwater runoff) are summarised with respect to the analysed parameters (general water quality constituents, hydrocarbons and heavy metals); furthermore the range of the EMC, in terms of mean value and standard deviation, across the whole monitoring campaign is reported.

From findings of elaboration, relevant EMC values emerge only for COD (Chemical Oxygen Demand). By comparing EMC values with the quality standards for direct discharging into the receiving water bodies (Annex 5 – Italian Decree by Law 152/06 according to the EC Dir. 91/271), results indicate that EMC_{mean} values for TSS (70 mg/l) is below the quality standard equal to 80mg/l. However, it can be noticed that the EMC values are strongly variable across the whole monitoring programme as confirmed by the standard deviation value, in addition looking at the maximum concentration values, in 13 over 19 rainfall-runoff events the peak values exceed the quality standard. By comparing the total suspended solids concentration values observed at VARESE IN and VARESE OUT gauge stations (corresponding to the untreated and treated storm water runoff), it clearly emerge that the on-line tank is effective in reducing the TSS value. Indeed the EMC_{mean} value is down by half in the treated runoff compared to the inlet TSS load. Furthermore, even the peak value exceeding the quality standard are limited to 5 across the whole monitoring programme.

The COD values observed at the inlet of the treatment system significantly exceed the Italian quality standard equal to 160 mg/l. Except at the beginning of the monitoring programme (rainfall-runoff events monitored between December 2011 and January 2012), the EMC value for COD is fairly constant across the monitoring programme, ranging from 255 mg/l to 312 mg/l. By comparing the total suspended solids concentration values observed at VARESE IN and VARESE OUT gauge stations, results indicate that the on-line tank is totally ineffective in limiting the discharge of COD into the receiving water body: the EMC_{mean} values observed for untreated and treated storm water runoff are equal to.239 mg/l and 231 mg/l respectively.

As for the total hydrocarbons, it is clearly emerge that the pollutant load observed in storm runoff is limited (generally below 1 mg/l) if compared with the Italian quality standard equal to 5 mg/l. The exception occurs only for the 26 October 2012 where the peak value is one order of magnitude greater than the discharge limit. By comparing the total suspended solids concentration values observed at VARESE IN and VARESE OUT gauge stations, it can be noticed that the EMC_{mean} value is down by half, even the inflow pollutant load is scarce. It is important to observe that the behaviour of total hydrocarbons is similar to the one observed for TSS. Taking into account that the HC concentration values include both the dissolved and the particulate fractions, such results seem to indicate that the HC are aggregate to the TSS fraction thus enhancing the effectiveness of the treatment system.

The heavy metals investigated in this monitoring programme are significantly reduced compared both the concentration values observed in runoff from urban paved surfaces and the Italian quality standard. Since the monitored area is a Municipal waste depot where the waste is stored directly on the paved surface or in special open containers, results indicate that the stored materials do not contribute to the metal leachate. The exception occur with respect to zinc at the beginning of the monitoring programme (rainfall-runoff events monitored between December 2011 and January 2012) when higher zinc concentration values are observed. By comparing the metals concentration values observed at VARESE IN and VARESE OUT gauge stations, results indicate that the on-line tank is totally ineffective in limiting the discharge of heavy metals into the receiving water body. Since the laboratory analyses have been performed only with respect to the dissolved fraction, such result is expected since the dissolved fraction of heavy metals thus not easily removed by a simple sedimentation process.

In conclusion results of the monitoring programme indicate that the pollutant load associated to storm runoff of the Municipal waste depot is limited. The pollutant load expressed in terms of acute values and EMCs are generally below the quality standards for direct discharging into the receiving water bodies (Annex 5 – Italian Decree by Law 152/06 according to the EC Dir. 91/271). The only exception occurs for the COD whose values exceed the quality standard across the whole monitoring programme. In addition, the total suspended solids, dissolved zinc and total hydrocarbon reveal acute concentration values exceeding the quality standards across the monitoring programme. Based on the characterization of the treated and untreated storm water runoff, the on-line tank seems to be not really effective because of the limited pollutant load flowing into the treatment system; in addiction the on-line tank is effective mainly in removing the load of settable solid particles that is limited in the site of concern. Due to such considerations, the on-line tank could be replaced with a macrophytes treatment system coupled with a small pre-treatment chamber (to remove the coarse material) thus enhancing the potential abatement of COD in case that the COD values are determined by organic matter.

Table 1 Concentration values (Event mean Concentration, maximum and minimum concentration) of water quality constituents (TSS, COD and HC) for each rainfall-runoff event monitored at VARESE-IN gauge station.

Parameter	TSS [mg/l]			COD [mg/l]			HC [mg/l]		
Rainfall Event	EMC	max	min	EMC	max	min	EMC	max	min
02/12/2011	19.3	30.0	4.0	31.55	64.79	4.05	0.33	1.13	0.09
03/12/2011	17.5	78.0	n.d.	31.54	68.83	4.05	*n.a.*	*n.a.*	*n.a.*
2-3/01/2012	94.5	146.0	16.0	14.75	40.49	4.05	0.15	2.19	0.12
03/04/2012	101.1	180.0	6.0	312.30	352.27	275.34	0.08	1.57	0.08
05/04/2012	48.3	200.0	2.0	265.71	287.49	255.09	0.22	1.84	0.11
7-8/04/2012	209.9	270.0	46.0	305.60	315.83	275.34	*n.a.*	*n.a.*	*n.a.*
15/04/2012	4.0	8.9	n.d.	263.03	271.29	251.04	0.30	0.39	0.04
18-19/04/2012	25.9	153.3	2.0	273.12	323.93	251.04	0.02	8.48	0.02
20-21/05/2012	23.5	100.0	2.0	256.44	283.44	242.95	0.15	1.09	0.11
26/08/2012	221.8	690.0	20.0	303.53	457.55	263.19	0.01	2.58	0.01
01/09/2012	32.5	39.5	39.5	294.15	295.58	287.49	0.04	1.05	0.04
03/09/2012	19.8	52.6	35.9	255.20	283.44	247.00	0.03	0.83	0.03
24/09/2012	36.0	60.4	60.4	301.13	315.83	279.39	0.04	0.04	0.04
25-26/09/2012	142.1	168.0	38.9	281.35	291.54	263.19	0.01	0.02	0.01
29/09/2012	56.7	90.9	38.3	278.58	291.54	271.29	0.01	0.02	0.01
11/10/2012	54.2	96.3	39.5	263.70	283.44	242.95	0.02	0.03	0.02
15/10/2012	100.5	245.7	40.1	275.87	303.68	251.04	*n.a.*	*n.a.*	*n.a.*
26/10/2012	55.4	99.2	40.7	272.15	323.93	251.04	0.86	57.25	0.09
10/11/2012	75.4	151.8	36.5	259.50	336.08	242.95	0.03	0.98	0.01
All event Mean	70.5			238.91			0.13		
All event SD	62.5			96.35			0.21		
All event Median	54.2			272.15			0.03		

Table 2 Concentration values (Event mean Concentration, maximum and minimum concentration) of water quality constituents (Cu, Pb and Zn) for each rainfall-runoff event monitored at VARESE-IN gauge station.

Parameter	Cu [µg/l]			Pb [µg/l]			Zn [µg/l]		
Rainfall Event	EMC	max	min	EMC	max	min	EMC	max	min
02/12/2011	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	198.70	907.90	80.20
03/12/2011	24.7	32.0	16.0	49.12	150.00	30.00	58.22	367.00	12.90
2-3/01/2012	17.0	21.0	4.0	n.d.	n.d.	n.d.	113.54	169.80	41.20
03/04/2012	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
05/04/2012	9.9	14.1	5.0	0.87	1.69	0.15	9.83	13.07	9.43
7-8/04/2012	13.4	21.1	11.8	0.51	2.61	0.01	11.01	13.00	9.97
15/04/2012	10.6	12.6	5.7	1.75	4.20	0.29	8.53	12.30	5.93
18-19/04/2012	9.3	19.3	0.6	4.66	13.78	0.72	28.07	85.75	0.05
20-21/05/2012	12.6	29.7	2.0	16.17	75.85	0.02	6.36	8.96	5.35
26/08/2012	8.8	32.4	4.7	0.89	6.29	0.42	7.98	9.81	6.26
01/09/2012	8.5	9.0	8.4	0.89	1.02	0.86	10.06	10.16	9.60
03/09/2012	3.0	6.5	1.1	0.46	0.68	n.d.	8.18	9.36	9.01
24/09/2012	4.8	8.8	2.1	0.86	1.53	0.41	8.99	10.63	7.88
25-26/09/2012	9.7	18.1	2.2	2.34	3.01	1.28	8.08	14.49	1.50
29/09/2012	8.9	10.8	8.0	1.07	1.24	0.92	7.76	14.16	3.90
11/10/2012	8.2	17.4	4.5	1.62	5.19	0.01	9.75	11.40	9.01
15/10/2012	8.1	16.5	2.1	2.36	23.83	0.23	9.57	11.24	8.07
26/10/2012	2.8	22.0	1.4	0.61	9.05	0.05	19.77	47.23	9.83
10/11/2012	3.0	6.1	1.3	1.35	3.19	0.56	39.35	98.70	9.87
All event Mean	9.6			5.03			31.32		
All event SD	5.4			11.96			49.58		
All event Median	8.9			1.07			9.79		

Table 3 Concentration values (Event mean Concentration, maximum and minimum concentration) of water quality constituents (TSS, COD and HC) for each rainfall-runoff event monitored at VARESE-OUT gauge station.

Parameter	TSS [μg/l]			COD [μg/l]			HC [μg/l]		
Rainfall Event	EMC	max	min	EMC	max	min	EMC	max	min
02/12/2011	18.4	24.0	14.0	19.66	60.74	4.05	0.20	0.86	0.09
03/12/2011	1.0	14.0	2.0	2.02	52.64	4.05	n.a.	n.a.	n.a.
2-3/01/2012	7.7	14.0	n.d.	17.01	48.59	4.05	n.a.	n.a.	n.a.
03/04/2012	-	-	-	-	-	-	-	-	-
05/04/2012	34.1	40.0	20.0	265.27	287.49	263.19	n.a.	n.a.	n.a.
7-8/04/2012	54.6	120.0	2.0	281.82	299.63	259.14	0.11	1.98	0.11
15/04/2012	6.1	33.3	2.2	260.85	392.76	242.95	0.06	0.53	0.03
18-19/04/2012	7.6	77.1	2.5	268.20	279.39	247.00	0.04	0.33	0.01
20-21/05/2012	16.3	26.7	10.0	262.53	311.78	247.00	0.13	0.64	0.13
26/08/2012	128.3	300.0	20.0	289.61	340.12	263.19	0.02	2.15	0.01
01/09/2012	40.6	52.0	38.3	308.43	311.78	307.73	0.03	0.69	0.03
03/09/2012	31.7	56.8	38.9	307.28	319.88	287.49	0.04	0.74	0.04
24/09/2012	7.1	39.5	39.5	271.70	275.34	255.09	0.11	0.13	0.11
25-26/09/2012	105.0	117.8	47.2	281.98	287.49	259.14	0.03	3.81	0.02
29/09/2012	n.a.	n.a.	n.a.	273.13	303.68	259.14	0.01	0.02	0.01
11/10/2012	50.2	56.2	38.1	271.39	332.03	247.00	n.a.	n.a.	n.a.
15/10/2012	46.0	96.9	37.1	259.52	275.34	247.00	n.a.	n.a.	n.a.
26/10/2012	37.4	40.7	35.3	261.03	275.34	247.00	0.03	0.33	0.02
10/11/2012	45.2	90.9	35.4	261.41	332.03	238.90	0.21	0.98	0.04
All event Mean	35.4			231.27			0.06		
All event SD	34.8			101.59			0.07		
All event Median	32.9			266.73			0.03		

Table 4 Concentration values (Event mean Concentration, maximum and minimum concentration) of water quality constituents (Cu, Pb and Zn) for each rainfall-runoff event monitored at VARESE-OUT gauge station.

Parameter	Cu [μg/l]			Pb [μg/l]			Zn [μg/l]		
Rainfall Event	EMC	max	min	EMC	max	min	EMC	max	min
02/12/2011	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	24.41	35.20	2.70
03/12/2011	2.7	34.0	15.0	n.d.	n.d.	n.d.	2.79	276.50	21.60
2-3/01/2012	3.8	9.0	2.0	n.d.	n.d.	n.d.	151.60	633.20	0.60
03/04/2012	-	-	-	-	-	-	-	-	-
05/04/2012	11.2	12.0	8.5	0.15	0.21	0.03	10.28	13.15	9.83
7-8/04/2012	13.0	20.0	0.6	0.88	6.61	0.48	9.01	13.00	8.10
15/04/2012	9.8	12.2	6.7	3.06	4.49	2.02	23.26	86.49	5.61
18-19/04/2012	7.5	15.5	0.2	5.37	7.72	2.41	n.d.	n.d.	n.d.
20-21/05/2012	4.3	6.2	2.7	0.04	0.07	0.02	6.24	8.83	5.40
26/08/2012	4.8	8.7	2.4	0.67	1.42	0.22	5.28	10.75	0.55
01/09/2012	1.7	3.3	1.3	0.55	0.64	0.53	8.96	9.76	8.80
03/09/2012	3.8	4.4	2.6	0.60	0.73	0.38	9.29	10.62	8.01
24/09/2012	3.9	5.0	3.7	0.65	0.96	0.58	9.29	9.35	9.03
25-26/09/2012	5.9	9.1	3.9	1.31	2.11	1.10	4.94	7.50	2.50
29/09/2012	2.8	4.1	2.0	1.70	2.02	1.30	3.86	5.10	1.80
11/10/2012	4.5	8.1	2.3	0.87	2.50	0.28	9.67	11.61	8.93
15/10/2012	3.8	6.1	2.0	0.67	2.87	0.39	6.26	10.58	2.07
26/10/2012	3.8	10.0	0.0	0.68	1.33	0.23	61.17	98.00	15.84
10/11/2012	1.9	3.2	1.1	0.93	2.02	0.59	14.42	33.22	9.47
All event Mean	5.0			1.01			21.22		
All event SD	3.4			1.32			36.31		
All event Median	3.9			0.67			9.29		