Bayfield Beach Stormwater Monitoring 2014

Prepared for the Bluewater Beach Committee

by
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Photo: Citizen scientists collecting water samples at the Bayfield Main Beach

Introduction

Communities along the southeast shore of Lake Huron largely depend on the tourism industry and the abundance of swimming, fishing and boating opportunities that the lake provides. Increased levels of bacteria, nutrients and sediment however, can result in degraded water quality and ultimately limit recreational opportunities. These contaminants are largely associated with both agricultural and urban non-point source pollution that gets washed into rivers, creeks and storm sewers during snow melts and rain events.

Since 2011 residents of the Main Bayfield watershed have been actively involved in a community-based watershed planning process to help improve water quality within the Bayfield River, which flows into Lake Huron at the village of Bayfield. The Bayfield Main Beach has been a recipient of the internationally-recognized Blue Flag program, which among other things, identifies beaches that meet strict criteria for water quality. In order to help maintain this certification and support water quality initiatives in the area, the Bluewater Beach Committee was formed. This partnership involves the Pioneer Park Association, Municipality of Bluewater, Huron County Health Unit, and Ausable Bayfield Conservation Authority (ABCA).

As the village of Bayfield has stormwater outlets along the beach, a stormwater monitoring program was initiated in the summer of 2014. The goal of this program was to gather some initial water quality data from the stormwater outfalls along the beach at the village of Bayfield. This information will help in determining whether the stormwater from the village of Bayfield might be impacting the beach and nearshore water quality.

Methods

Site Description

Water quality was monitored at four stormwater outfalls along the beach adjacent to the village of Bayfield, Ontario, and at one culvert along the road (Tuyll Street) adjacent to the shoreline (Figure 1). Two of the four outfalls (BeachN and BeachS) were located along the beach adjacent to shoreline residences. BeachN consisted of two small pipes (approximately 102 mm each), and BeachS consisted of sheet flow from the base of a rock retaining wall. The Colina outfall (125 mm pipe) outletted at the top of the bank, while the Delevan outfall (750 mm) extended down the bank. Both were designated stormwater outlets for the village of Bayfield (BM Ross 2014). The Tuyll site was a culvert (~610 mm in diameter) running perpendicular to the shoreline at which overland flow had been observed. According to a report on storm drainage for the village of Bayfield (BM Ross 1985), existing tile drainage for the most developed portion of the village is directed towards the Delevan outfall or an open water course that discharges at the top of the bank (*i.e.*, Tuyll).

The village of Bayfield, which is within the Municipality of Bluewater, is mostly residential with businesses along its main street. It is serviced by the Bayfield Sewage Treatment Plant.

Water Sampling

Water samples were collected once in June, and then every other week during July and August beginning on July 7. These routine monitoring events took place on predetermined dates. They were not initiated by wet weather, but typically occurred during a dry weather day (dry sampling). Water samples were also collected after rain events (event sampling), which were characterized as greater than 2.6 mm of rain in less than one hour. If a rain event occurred overnight, sampling was done as soon as possible the following morning.

Grab samples were collected by holding the sample bottle within the flowing water from the outfall, and without touching surrounding surfaces. Water flowing at BeachS was in the form of sheet flow across a rock, so efforts were taken to minimize contact with the rock. If water was not flowing from the outfalls, no sample was collected, regardless of whether ponded water was observed below the outfall.

Figure 1. Approximate locations of five stormwater monitoring sites and public beaches along the Lake Huron shoreline in Bayfield, Ontario.

Upon the initiation of the project, water samples were analyzed by ALS Environmental in Waterloo, Ontario, to determine the concentrations of total phosphorus (TP) and soluble reactive phosphorus (SRP) in mg/L, and by the Public Health Laboratory in London, Ontario, to determine the concentrations of *Escherichia coli* (*E. coli*) in colony forming units per 100 millilitres of water (cfu/100 mL). Analysis of *E. coli* was transferred to ALS Environmental in Waterloo, Ontario beginning July 21 in order to obtain more precise *E. coli* concentrations since the Public Health Laboratory terminates *E. coli* counts once concentrations reach 1000 cfu/100 mL.

Data Interpretation

Geometric means were used to summarize *E. coli* and TP concentrations for each monitoring site. A geometric mean is a type of mean or average whereby the effect of uncommonly high or low concentrations on a mean is reduced. Geometric means (dry and event sampling) were calculated for each monitoring site for the months of June through August 2014. These geometric mean concentrations were compared to provincial guidelines for *E. coli* and TP. SRP and TP geometric mean concentrations were used to determine SRP as a percentage of the TP. In some cases SRP concentrations exceeded TP concentrations. These exceedances result from the analysis of separate aliquots of each water sample. Where SRP concentrations were higher than TP concentrations, percentages were determined to be 100 percent. Detection limits were used as actual concentrations for any *E. coli*, TP or SRP concentrations that came back from the lab as less than the detection limit.

Daily precipitation levels were helpful for understanding some of the variability in *E. coli* and phosphorus concentrations. Precipitation data were obtained from the rain gauge maintained by the ABCA near Varna, Ontario, which is the closest rain gauge to the village of Bayfield.

Results and Discussion

Escherichia coli

Escherichia coli (E. coli) are fecal coliform bacteria commonly found in the intestinal tract of warm-blooded animals. While *E. coli* itself is not a threat to the environment, its presence in water collected from drains may indicate contamination by other harmful bacteria, viruses, or parasites that are associated with animal wastes. Sources may include human, pets, livestock and wild animals. The Ontario Ministry of Health and Long-term Care established a recreational guideline for *E. coli* of 100 colony forming units (cfu) per 100 mL (MOEE 1994).

Concentrations of *E. coli* at the outfalls ranged from 0 cfu/100 mL at BeachS (August 12) to 3610 cfu/100 mL at Tuyll (July 28) (Table 1) (The range of *E. coli* concentrations may be under represented as counts completed by the Public Health Lab prior to July 21 terminated at 1000 cfu/100 mL.) Concentrations of *E. coli* at the Tuyll and Delevan outfalls tended to be higher than the water quality guideline, while *E. coli* concentrations were often well below the guideline at both BeachN and BeachS. No samples were collected from the Colina outfall. Although wet sand and pooled water were noted throughout the sampling period, flowing water was not observed at this outfall in 2014. Some of the elevated *E. coli* concentrations occurred following rain events (*e.g.*, July 7 and 28 sampling dates at Tuyll and Delevan); however, elevated concentrations also occurred during periods without rainfall (*e.g.*, August 5 at Tuyll and Delevan and August 18 at Tuyll). (Please refer to the Appendix for precipitation graphs.) This suggests that factors other than rainfall may influence bacteria concentrations in the outfalls.

Geometric mean *E. coli* concentrations at the outfalls ranged from 3 cfu/100 mL at BeachS to 605 cfu/100 mL at Tuyll for dry sampling, and increased to 5 cfu/100 mL at BeachS to 1356 cfu/100 mL at Tuyll following rain events (event sampling) (Figure 2). No dry sampling geometric mean was calculated for BeachN as no samples were collected from this outlet during dry sampling. Geometric mean *E. coli* concentrations at Tuyll and Delevan exceeded the provincial water quality guideline following rain events. This guideline, however, was also exceeded at Tuyll for dry sampling, which may indicate a more constant source of contamination.

Table 1. *Escherichia coli* concentrations, in colony forming units (cfu) per 100 mL on each sampling day in 2014 for five stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario. Highlighted values denote concentrations that exceed the Ontario Ministry of Health and Long-term Care guideline of 100 cfu/100 mL. Shaded columns indicate event sampling dates.

Site	Jun 12	Jul 7[b]	Jul 13[b]	Jul 14[b]	Jul 21	Jul 28[b]	Aug 5	Aug 12[b]	Aug 17	Aug 18
BeachN	ns	80	10	10	ns	23	ns	2	ns	ns
BeachS	10	10	10	10	2	2	1	0	ns	1
Colina	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Tuyll	210	1000*	1000*	1000*	240	3610	2020	1270	380	2090
Delevan	50	1000*	750	480	8	890	1880	210	10	7

[a] More than 10 mm of rainfall in 24 hours prior to sampling.
[b] More than 10 mm of rainfall in 48 hours prior to sampling.
[c] More than 70 mm of rainfall in 3 days prior to sampling.
ns = no sample was collected due to lack of flow.
* Concentration may be under represented as counts completed by the Public Health Lab terminated at 1000 cfu/100 mL.

Table 2. Total phosphorus (TP) and soluble reactive phosphorus (SRP) in mg/L on each sampling day in 2014 for five stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario. Highlighted values denote concentrations that exceed the Provincial Water Quality Objective (PWQO) of 0.030 mg/mL. Shaded columns indicate event sampling dates.

Site	Jun 12	Jul 7[b]	Jul 13[b]	Jul 14[b]	Jul 21	Jul 28[b]	Aug 5	Aug 12[b]	Aug 17	Aug 18
BeachN – TP	ns	0.047	0.047	0.032	ns	0.046	ns	0.049	ns	ns
BeachN - SRP	ns	0.045	0.049	0.030	ns	0.051	ns	0.052	ns	ns
BeachS – TP	0.006	0.004	0.004	0.004	0.008	0.006	0.005	0.004	0.006	0.006
BeachS – SRP	0.003	0.003	0.003	0.005	0.004	0.004	0.003	0.003	0.003	0.003
Colina – TP	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Colina – SRP	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Tuyll – TP	0.031	0.043	0.040	0.035	0.035	0.053	0.090	0.047	0.036	0.046
Tyull – SRP	0.031	0.039	0.037	0.033	0.041	0.052	0.041	0.045	0.003	0.048
Delevan – TP	0.058	0.061	0.050	0.046	0.050	0.059	0.232	0.063	0.057	0.065
Delevan - SRP	0.066	0.052	0.049	0.047	0.059	0.048	0.026	0.056	0.046	0.057

[a] More than 10 mm of rainfall in 24 hours prior to sampling.
[b] More than 10 mm of rainfall in 48 hours prior to sampling.
[c] More than 70 mm of rainfall in 3 days prior to sampling.
ns = no sample was collected due to lack of flow.

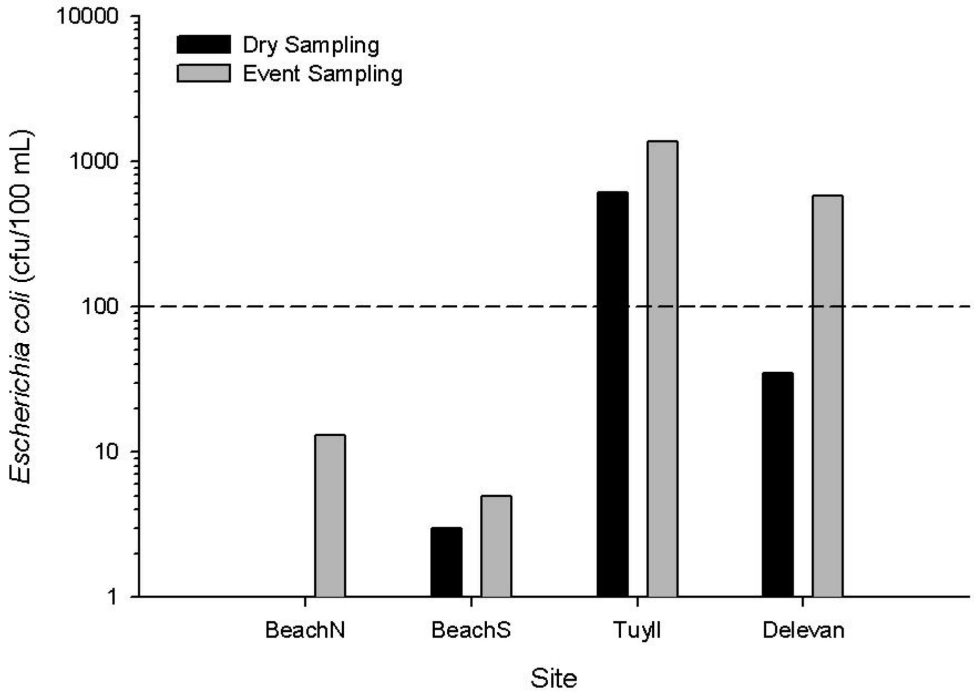

Figure 2. Dry (n=5) and event (n=5) sampling geometric mean *Escherichia coli* concentrations in colony forming units per 100 mL at four stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario in 2014. Dashed line indicates Ontario Ministry of Health and Long-term Care guideline of 100 cfu/100 mL.

Bacterial contaminants in urban stormwater can originate from both human and animal sources. Since the village of Bayfield has a separate system for sanitary sewers, *E. coli* contamination is more likely a result of stormwater runoff that has come into contact with domestic and/or wild animal waste. Pick up and proper disposal of pet waste should be encouraged throughout the village. It is also important the Municipality of Bluewater ensure there are no cross connections or leaks between sanitary sewers or old septic systems and stormwater drainage facilities in the areas drained by the Tuyll and Delevan outfalls.

The abundance of fecal bacteria has been strongly linked to the amount of impervious (not allowing water to pass through) surfaces within a watershed (Mallin *et al.* 2000). Protecting and creating green space in existing and new urban development is therefore an essential component of ensuring good water quality at the beach in the village of Bayfield. Low impact development (LID) is an approach to land development that mimics the natural movement of water in order to manage stormwater close to where it falls (CVC 2015). The following LID techniques reduce runoff in urban areas by increasing infiltration (process by which water on the ground surface enters the soil) and slowing water down:

- Naturalized landscapes (trees/shrubs/flowers absorb more rainwater than regular patch of grass)
- Rain barrels
- Rain gardens (shallow depressions that contain soil and plants that promote infiltration and treat pollutants)
- Green roofs (vegetation or roof-top gardens that absorb rainwater)
- Infiltration trenches/soakaways (underground reservoirs that collect and filter rainwater)
- Grass swales (open vegetated channels that slow stormwater, promote infiltration and trap and treat pollutants)
- Permeable pavement (concrete or asphalt that allows water to drain through and infiltrate into soil)

Total Phosphorus

Total phosphorus (TP) includes phosphorus that is dissolved in water and insoluble phosphorus that binds to organic and inorganic material in water. In many aquatic systems, phosphorus is the nutrient that limits plant growth. When phosphorus is added to the system, the first response may be increased plant and algae growth. These conditions can result in aesthetic concerns, especially along shorelines and public beaches. Nutrient over-enrichment can result in excess plant growth and algal blooms, which can negatively impact aquatic life and further impede recreational waters. The Government of Ontario established a Provincial Water Quality Objective (PWQO) for TP of 0.030 mg/L to prevent eutrophication (excessive algae and aquatic plant growth, shortened food chains, changes in the aquatic plant and animal communities) (MOEE 1994).

Concentrations of TP ranged from 0.004 mg/L at BeachS (various sampling dates) to 0.232 mg/L at Delevan (August 5) (Table 2). All TP concentrations at the outfalls exceeded the provincial water quality objective, aside from those at BeachS. No samples were collected from BeachN on dry sampling dates, and no samples were collected from Colina because of a lack of water flow at the time of sample collection.

Dry sampling geometric mean TP concentrations varied from very low concentrations of 0.006 mg/L at BeachS to 0.076 mg/L at Delevan. Event sampling concentrations were slightly lower across all sites and ranged from 0.004 mg/L at BeachS to 0.055 mg/L at Delevan (Figure 3). All dry and event sampling geometric mean TP concentrations exceeded the water quality objective, except for BeachS. These concentrations may therefore contribute to excess plant growth and aesthetic concerns along the beach. Filamentous algae was observed at Delevan throughout the sampling period.

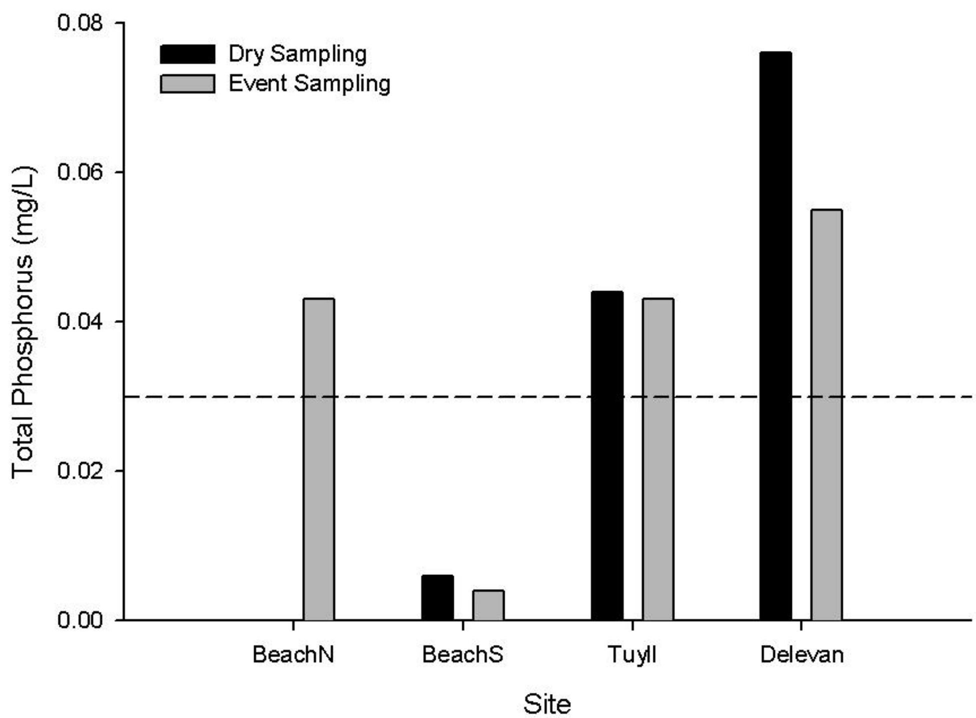

Figure 3. Dry (n=5) and event (n=5) sampling geometric mean total phosphorus concentrations in mg/L at four stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario in 2014. Dashed line indicates Provincial Water Quality Objective of 0.030 mg/L.

Although the data are limited (5 samples for dry sampling and 5 samples for event sampling), several scenarios could be occurring with regards to the TP concentrations at the outfalls. One such scenario is that there could be a consistent source of phosphorus reaching the outfalls that becomes diluted as rain water flushes through these systems, giving way to lower event sampling TP concentrations. Alternatively, some results from rural stormwater monitoring indicate that phosphorus concentrations are highest during the first flush (runoff that occurs at the beginning of a rain event) (Upsdell Wright and Veliz 2013). Given the current sampling procedures of this program the highest phosphorus concentrations could be missed depending on when the rain event begins and when samples are collected.

Soluble Reactive Phosphorus

Soluble reactive phosphorus (SRP), also known as phosphate, is the portion of phosphorus that is readily available to aquatic plants. This fraction of TP can stimulate algal growth and contribute to algal blooms, and the increased loading of SRP has been cited as the main cause of the recent blooms in Lake Erie (IJC 2014).

SRP varied from 0.003 mg/L at BeachS (various sampling dates) to 0.066 mg/L at Delevan (June 12) (Table 2). Event sampling produced SRP concentrations that ranged from 0.003 mg/L at BeachS (various sampling dates) to 0.056 mg/L at Delevan (August 12). No samples were collected from BeachN on dry sampling dates, and no samples were collected from Colina because of a lack of water flow at the time of sample collection.

SRP as a percentage of TP ranged from 54 percent at Tuyll to 64 percent at Delevan for dry event sampling dates (Figure 4). All outfalls had higher percentages of SRP following rain events (event sampling), which varied between 84 percent at BeachS to 100 percent at BeachN. These SRP percentages indicate there is potential for euthrophication and algal blooms to occur along the shoreline if other required conditions are also met (*e.g.*, temperature).

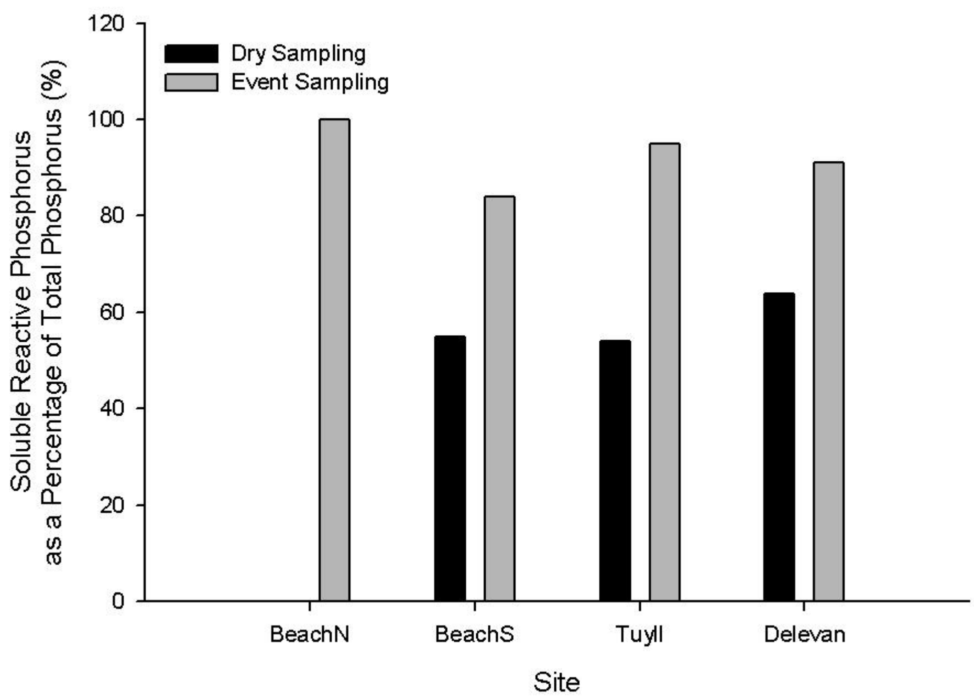

Figure 4. Soluble reactive phosphorus as a percentage of total phosphorus at four stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario in 2014.

Non-point sources of phosphorus in urban areas can originate from construction sites, lawn and garden activities, leaves and animal waste (IJC 2014). In order to improve water quality at the beach and prevent algal blooms, the following actions can be taken to reduce phosphorus inputs to stormwater systems:

- Protect and create more naturalized areas
- Establish ground covers or use mulch on bare soil to prevent runoff
- Plant native plants, which require less fertilizer and water
- Install rain barrels
- Install filter strips, grass swales and rain gardens to slow water and increase filtration
- Reduce or eliminate the use of fertilizers containing phosphorus
- Leave lawn clippings and mulch leaves as opposed to piling leaves on the curb sides
- Clean eavestroughs and install gutter guards
- Properly dispose of pet waste
- Use designated car wash centres to wash vehicles
- Use permeable pavement to increase filtration

Next Steps

1. Continue to monitor water quality, specifically *E. coli*, total phosphorus and soluble reactive phosphorus at the Tuyll and Delevan stormwater outfall sites. Results from 2014 do not warrant any further testing of *E. coli* at BeachN and BeachS, but further investigation into possible phosphorus sources may be necessary at BeachN.
2. As part of the stormwater master plan for the village of Bayfield, gain a better understanding of the watershed drained by the Tuyll outfall.
3. Engage the local community with information about stormwater management and low impact development technologies (*e.g.*, rain barrels, rain gardens) through outreach activities of the Main Bayfield Watershed Plan.
4. Support community actions such as a demonstration rain garden.
5. Assist the Municipality of Bluewater in implementing low impact development technologies (*e.g.*, permeable pavement, grass swales, rain gardens) for existing infrastructure and proposed developments.

Helpful Links

http://www.creditvalleyca.ca/low-impact-development/

http://www.creditvalleyca.ca/low-impact-development/low-impact-development-support/green-technology-projects/green-projects-map/

http://www.lsrca.on.ca/programs/rainscaping/LID-retrofits.php

Acknowledgements

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Appendix

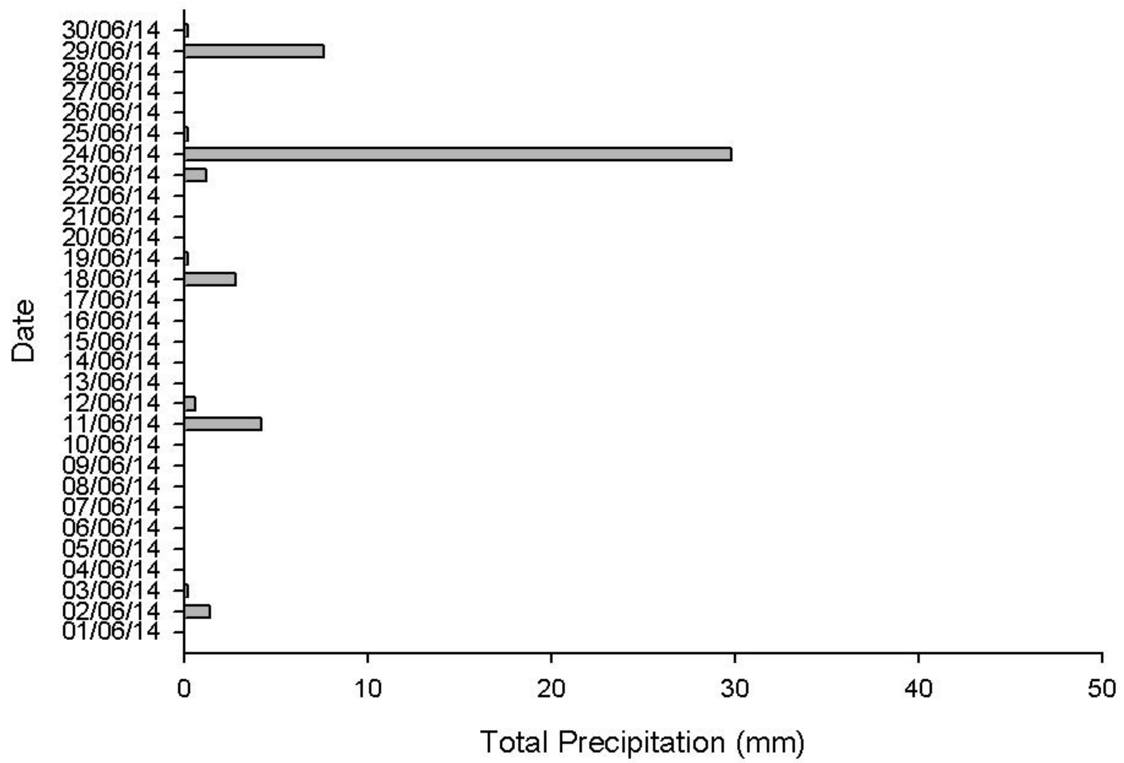

Figure A1. Total daily precipitation at Varna during June 2014.

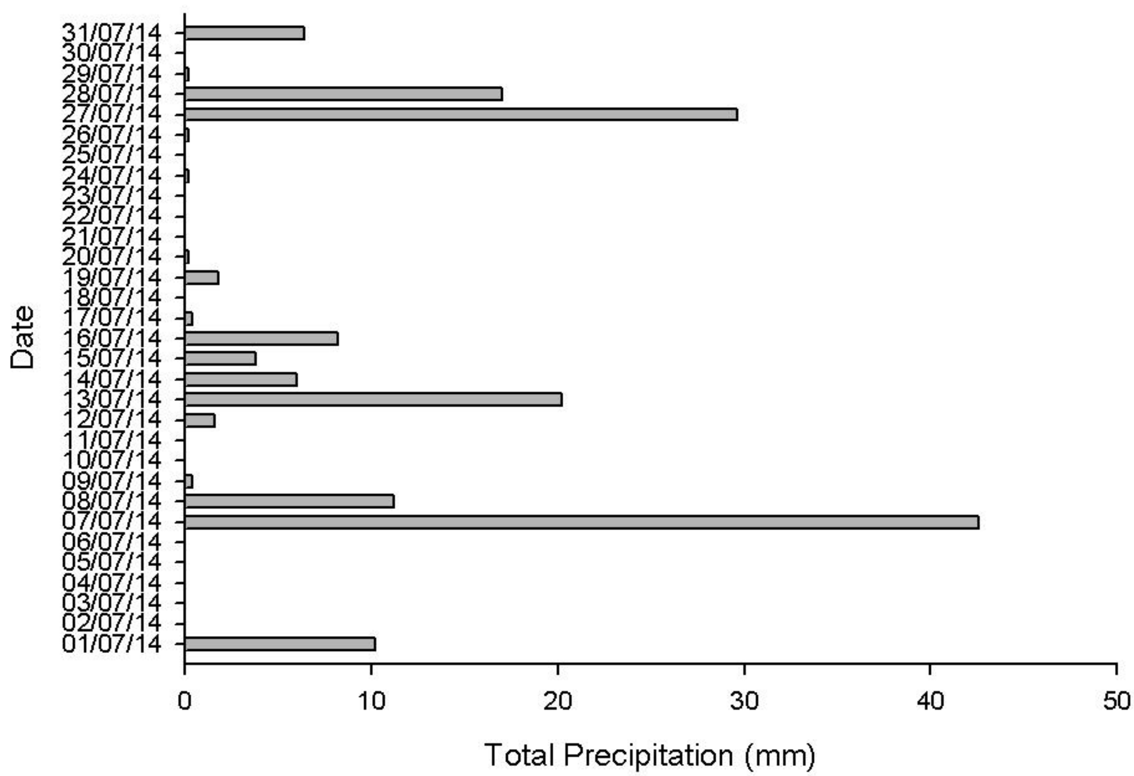

Figure A2. Total daily precipitation at Varna during July 2014.

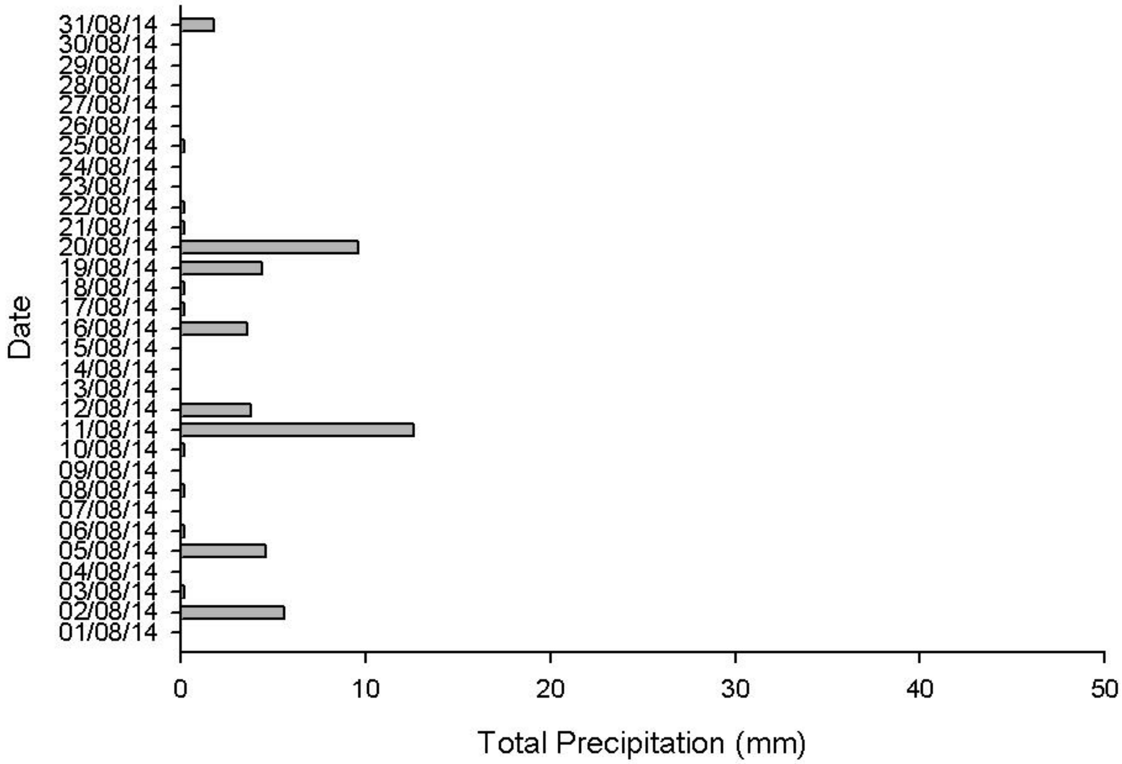

Figure A3. Total daily precipitation at Varna during August 2014.