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Comparing Non-Point Source Pollution Total Solids (TS), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), and pH in the Molly Ann Brook and the Passaic River, in Paterson Area-New Jersey Using EPA Test Method

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Abstract

Urbanization, industrialization and industrial waste can affect water and soil properties. New Jersey's the Passaic River and the Molly Ann Brook River have been a heavily polluted industrial waterway, for more than a century. In this study, we have been determined and evaluated the water quality parameters of a surface water sample by comparing Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), and pH values in the Molly Ann Brook River, and the Passaic River, in Paterson Area, New Jersey using EPA test Methods. The results indicated that TS and TDS levels fall within acceptable limits, while TSS concentrations and pH values deviated from the expected ranges.

Keywords

Total Solid (TS), Total Suspended Solid (TSS), Total Dissolved Solid (TDS), pH

1. Introduction

The Molly Ann Brook watershed traverses 7.8 miles of Passaic County within the Passaic River in Paterson; upstream, midstream and confluence with Passaic River. This waterway is situated between the northern stretches of First Watchung Mountain and Second Watchung Mountain, specifically within Passaic and Bergen Counties in New Jersey. Molly Ann Brook river passes through south from its

headwaters in the Haledon Reservoir outlet in North Haledon to the Passaic River in Paterson. The New Jersey Department of Environmental Protection (NJDEP) identifies the Molly Ann Brook as an impaired watershed that does not meet Surface Water Quality Standards.

The Passaic River is one of the major rivers in northern New Jersey. The Passaic River is 129 km long (about 80 miles) long [1] [2] and flows through the northern New Jersey; upstream (above Paterson), midstream (Paterson Falls), and downstream.

In 1983, the United States Environmental Protection Agency (U.S.EPA) identify the Passaic River as the second most polluted river in the United States because of Diamond Alkali site investigation showed extremely high levels of hazardous chemicals [3]. Contaminants in the river PAHs, PCDD/F, PCBs, DDT, ammonia, pesticides and their byproducts, and heavy metals including Hg, Cr, and Pb. This fact is tragic. But no single hazardous substance, and no single source, is solely to blame. Over the last century, hundreds of companies among them, factories, refineries, and manufacturers of all types polluted the Passaic River countless hazardous substances [4].

In 2013, several corporate defendants agreed to pay the State of New Jersey $130 million for ecological damages related to Passaic River pollution. However, it is unclear as to whether the state will actually use this money for clean-up efforts [5].

The New Jersey Department of Environmental Protection (NJDEP) issued notices in 2009 banning commercial fishing caught in the tidal Passaic River should not be eaten [6]. The fish consumption advisories remain in effect as of 2020 [7].

2. Experimental

2.1. Total Solid (TS) (Residue, Total, Turbidity)

Total solids, closely related to TSS, measure the cloudiness or haziness of water caused by suspended particles. Total solid is the solid remaining after the evaporation of the sample to constant weight at a temperature of 105˚C. The Passaic River and the Molly Ann Brook River's turbidity is often elevated after heavy rainfall events due to increased runoff carrying sediment and debris into the rivers.

Sample Handling and Storage

10 water samples collected in clean sterile plastic containers every 250 meter of the Passaic River (total length 2.5-kilometer), and 100 meter of the Molly Ann Brooke River (total length 1-kilometer). Samples were mixed to form 1-liter composite samples, and stored at 4˚C during transport to the laboratory. Sample holding time is 7 days.

Materials/Equipment

- Porcelain Crucible
- Drying oven with a thermometer at 103 - 105˚C
- Analytical balance

Procedure

A clean porcelain or metal crucible is dried in a 103 - 105˚C oven muffle fur-

nace, allowed to cool in a desiccator, and weighed on an analytical balance. A 50 mL measured volume of well-mixed waste water is poured into the crucible. The crucible is then placed in a drying oven set at about 95˚C until all free liquid is evaporated. Once all free liquid has evaporated, the temperature of drying oven is increased to 103 - 105˚C for 1 hour. The crucible is then removed from the drying oven, allowed to cool in a desiccator, and weighed on an analytical balance. The difference in the initial and final weights is used to calculate the concentration in mg/L (ppm) (Table 1).

$$\text{TS} = \frac{\text{weight of residue}}{\text{sample volume}} \times 10^6 \quad \text{mg/L (ppm)}$$

Table 1. Results of Total Solids (TS).

Location	Season	Crucible Tare (g)	Sample volume (mL)	Crucible + Residue (g)	Residue (g)	TS (mg/L) at 105˚C	Average TS (mg/L)
Molly Ann Brook, Paterson NJ	Spring	28.8260	50	28.8422	0.0162	325	327
Duplicate		28.8266	50	28.8430	0.0164	328	
Passaic River, Paterson, NJ	Spring	29.7218	50	29.7356	0.0138	276	278
Duplicate		29.7220	50	297360	0.0140	280	

2.2. Total Suspended Solids (TSS) (Residue, Settleable)

TSS actually is a combination of floatable, settlable, plankton and algae, plants decay, and suspended solids retained by the cellulose ester or glass-fiber filter. 1.5 micron (μm) glass-fiber filter used in the TSS, all particulates larger than 1.5 μm will be retained on the TSS glass-fiber filter. Furthermore, TSS can carry pollutants like heavy metals and pesticides, which can accumulate in sediments and pose long-term risks to the ecosystem and human health. The Passaic River and the Molly Ann River, particularly in its lower reaches, have historically suffered from elevated TSS levels due to industrial discharge, urban runoff, and erosion from construction activities.

Gravimetric analysis is one of the most widely used methods for measuring TSS in water and wastewater. This is a quantitative method, based on EPA Method 160.2 [8].

Materials/Equipment

- Glass fiber filter 1.5 micron (μm) Whatman grade 934 H
- Filtration apparatus
- Suction flask
- Vacuum pump
- Drying oven with a thermometer at 103 - 105˚C
- Analytical balance

Procedure

A specific type and size of glass fiber filter is placed in a weigh pan (dish), dried in a 103 - 105˚C oven, and then allowed to cool in a desiccator. Then initial weight of the filter is then determined on an analytical balance and recorded. The glass-fiber filter is fitted into a clean filter funnel or filter crucible, and the funnel or crucible is attached to a stopper in the top of a sidearm flask connected to a vacuum system. The vacuum system is turned on, creating suction, and the glass-fiber filter is rinsed with deionized (DI) water to ensure proper eating. A measured, well-mixed 50 mL of waste water is poured into the funnel and allowed to drain under suction until all free water moves through the filter. The sides of the funnel are washed three times with 10 mL of DI water to ensure no solids remain outside of the filter. The filter is carefully removed from the filter and placed back in the original weigh pan. The weigh pan and filter are again dried in a 103 - 105˚C oven and then allow to cool in a desiccator. The final weight of the filter is determined on an analytical balance. The difference between the initial and final pan/filter weights are used to calculate the concentration (mg/L) of TSS based on the volume of waste water (Table 2) [9].

$$\text{TSS} = \frac{\text{Weight of solids } (\text{mg})}{\text{sample volume } (\text{mL})} \times 1000 \text{ mg/L (ppm)}$$

Table 2. Results of TSS.

Location	Season	Pan + Glass-fiber filter (g)	Sample volume (mL)	After drying pan + glass fiber at 105˚C (g)	Residue (g)	TSS (mg/L) at 105˚C	Average TSS mg/L
Molly Ann Brook, Paterson NJ	Spring	1.8038	50	1.8126	0.0088	176	178
Duplicate		18042	50	1.8132	0.0090	180	
Passaic River, Paterson, NJ	Spring	1.7983	50	1.8065	0.0082	164	166
Duplicate		1.7986	50	1,8070	0.0084	168	

2.3. Total Dissolved Solids (TDS) (Residue, Filterable)

The total amount of substances dissolved solids consisting of organic and inorganic compounds that dissolved in water [10]. Waters high in TDS often contain object ionable levels of dissolved salts. Total dissolved solids represent an integrative measure of the concentration of common ions such as Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, $SO4^{2-}$ and bicarbonate [11]. Thus high TDS may indicate the presence of other water problems.

Sample Handling and Storage

Sample collected in clean sterile polyethylene containers at 10 different locations, collected wastewater samples below surface level (about 0.3 m); mixed them

up, make it 1 liter. Transport on ice box to the lab. Stored at 4˚C to minimize microbiological decomposition of solids, during transport to the laboratory, and analyze within 24 hours. Sample holding time is 7 days.

Materials/Equipment

- Desiccator
- Porcelain evaporation dish 100 mL
- Suction flask, 500 mL
- Vacuum pump
- Drying oven with a thermometer at 181˚C
- Analytical balance

Procedure

Pre weigh evaporating dish. Filter 50 mL of river water samples in an evaporating dish. Place it in drying oven at 181˚C for 4 hours. Cool to room temperature in the desiccator and weigh again. Calculated as follows (Table 3):

$$\text{TDS} = \frac{\text{Residue of particles}}{\text{sample volume}} \times 10^6 \text{ mg/L (ppm)}$$

Table 3. Results of TDS.

Location	Season	crucible (g)	Sample volume (mL)	After drying crucible + residue at 181˚C (g)	Residue (g)	TDS (mg/L) at 181˚C	Average TDS mg/L
Molly Ann Brook, Paterson NJ	Spring	29.4124	50	29.4178	0.0054	108	110
Duplicate		29.4128	50	29.4184	0.0056	112	
Passaic River, Paterson, NJ	Spring	29.4136	50	29.4182	0.0046	92	94
Duplicate		29.4140	50	29.4188	0.0048	96	

2.4. pH Determination

To determine if pH and temperature is effected by nonpoint source pollution in the Passaic River and Molly Ann Brook. The Environmental Protection Agency (EPA) has certain criteria's for the Passaic River in regards to pH and temperature. The climate, air temperatures and precipitation in the region, have a significant impact on the water quality in our watershed. The precipitation this spring has been above normal. While the temperature range is recorded lower than average. This information is based on the EPA findings. With precipitation higher than normal does the run-off from non-point source pollution such as road salt and fertilizer effect the temperature and pH of the Passaic River and Molly Ann Brook.

To determine if the Passaic River and Molly Ann Brook's pH and temperature is effected by non-point pollution and climate, in accordance to the ranges to set forth by the EPA requirements of these watersheds.

Apparatus

pH meter consisting of potentiometer, a glass electrode, a reference electrode, and a thermometer.

Procedure

Measurements of pH: Samples were collected from 10 locations along the Molly Ann Brook and 10 locations along the Passaic River in the West Side Parks. The samples were mixed and there was one jar. pH meter was calibrated using pH buffer solution 4.01 and 7.00 for acidic sample, and pH buffer solution 7.00 and 10.00 for the basic solutions. The pH samples were measured immediately after sample collecting in accordance with regulatory requirements of 15 minutes (Table 4).

Table 4. Measurements results of pH and temperatures.

Date of sample collection May 9	pH			Average pH	Temperature
Passaic River	6.12	6.10	6.11	6.11	16˚C
Molly Ann Brook	6.20	6.22	6.21	6.21	14.5˚C

3. Results and Discussion

Passaic River near Paterson was heavily polluted by the industrial wastes. Passaic Valley Water Commission (PVWC) and U.S. Geological Survey (USGS) and NJDEP Monitoring Station near Paterson providing continuous data for water quality parameters. No readily specifications data available for Molly Ann Brook River. In this study, we have been determined and reported pollution results shown on Table 5 [12]-[15]. The observed acidic pH values of 6.11 and 6.21 fall below the neutral pH of 7.0, indicating the presence of acidic inputs. A likely contributor is non-point source pollution, which includes diffuse sources such as agricultural runoff, urban storm water, and atmospheric deposition (Table 4). Acid rain formed when sulfur dioxide (SO_2) and nitrogen oxides (NOx) from fossil fuel combustion react with water vapor, can lower the pH levels in receiving waters.

Table 5. Comparison results.

Parameter	Expected Range, mg/L [16], [17]	Molly Ann Brook Average, mg/L (ppm)	% RPD	Passaic River Average mg/L (ppm)	% RPD
TS	100 - 600	327	0.92	278	1.44
TSS	NMT 30	178	2.24	166	2.41
TDS	100 - 600	110	3.64	94	4.26
pH	6.5 - 8.5	6.21	-	6.11	-

4. Conclusion

A comparative study using standardized EPA Methods (160.1 & 160.2) always qualifying and understanding the differences in water quality between two inter-

connected water bodies. These metrics are essential for; identifying pollution sources, assessing compliance with environmental standards (NJDEP, EPA), and guiding watershed management efforts. Environmental Impact; elevated solids can reduce light penetration, harm aquatic life, and affect water quality for drinking or recreation. Total Suspended Solids (TSS) (Table 2) results in both Molly Ann Brook River and the Passaic River are higher than the expected range. The average pH result is lower than expected range., because run-off, bank erosion, and possible construction activity. Total Dissolved Solids (TDS) (Table 3) differences, could indicate more road salt (such as $CaCl_2$) usage, wastewater discharge, or industrial pollution in the Passaic and Paterson area.

These findings suggest partial non-compliance with water quality standards and highlight the need for further investigation and potential remediation strategies.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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