

INTRODUCTION AND HYPOTHESIS

Introduction

Researchers have used different ways to determine the quality of a stream. Stream water, stream sediment and the biodiversity of macroinvertebrates have been used primarily. Certain organic compounds, heavy metals, nitrogen, phosphorous, e-coli bacteria and pH concentrations present in the stream are some factors which can affect the stream quality. Emissions from various industrial facilities located along or near the stream can be the source or cause of these factors.

Many industrial facilities along Jordan Creek have emitted substances into the stream for many years. Lumber yards, metal working and electroplating factories, photographic labs, trash dumps, gas stations, painting and printing shops were some of the past sources of emissions into the creek which flows through Springfield, Missouri. There are still many of the same type facilities today built along the stream which can affect the creek.

Hypothesis

I believe the heavy metal concentrations in the stream sediments in certain portions of Jordan Creek are much higher in some areas along Jordan Creek as compared to other areas. I also believe that the biodiversity of macroinvertebrates present in the stream sediments will be lower in the sediments with higher heavy metal concentrations than in sediments which have lower heavy metal concentrations. I believe using an ICP analysis machine will let me determine where along the stream the high and low concentrations of heavy metals are located. Also, I believe by identifying the species of different macroinvertebrates in the bottom stream sediments and on rocks, and using a Pollution Tolerance Index (P.T.I.), the quality of the stream at that location can be determined.

PROCEDURE

Stream Sediment Samples

Eleven Jordan Creek sediment samples were collected in the less industrial area along the stream. These samples represent the control for the study. Fifteen samples were collected in the more industrial area of the stream and are the research test samples. Samples were stream sediments collected in the stream water and not soil located along the stream bank. Each sample was collected with a hand hoe and placed in a labeled sandwich bag.

The samples bags were opened in my basement and the pH of the sediment water was taken and recorded for each sample using a hand held pH meter. Each sample was allowed to dry completely, disaggregated in a mortar and pestle, passed through a 100 mesh standard sieve and transferred to a labeled bottle.

The samples were taken to a Geology Lab at Southwest Missouri State University. Each sample was weighed to 1.00 gram, recorded and placed in a labeled centrifuge bottle. Twenty milliliters of 3 normal (3N) nitric acid were added to each centrifuge bottle. All the samples were placed in a hot water bath for 24 hours at 60 degrees Celsius and agitated at 50 rpm. Each sample was placed in a high speed centrifuge for 4 minutes and the liquid portion poured into a labeled analysis bottle for chemical analyses.

The As, Cu, Pb, Zn, Ag, Cd, P, Cr and Ni concentrations in each sample were determined by using a Varian Induced Couple Plasma (ICP) Machine. Standard solutions of 3 different concentrations of each element was used with a blank solution to help determined the element concentrations. The standards were pre-prepared by the Chemistry Department. Each sample was entered into the ICP machine and data from a printout for each element for each sample was used to calculate the metal concentrations.

Macroinvertebrate Samples

The locations and trends of heavy metal concentrations in the stream sediments were observed to establish the collection sites of the macro invertebrate samples. Because of the cement channelization in some areas along Jordan Creek and the affects it has on microinvertebrate development, collection sites were limited to the areas along the creek where natural stream beds were located. Three sites were chosen in the less industrialized portion along the stream (control group) and three sites in the more industrialized area (test group).

The sediments and rocks at each collection site were searched for the different species of macroinvertebrates (bugs). At each site, a picture of the typical bugs (species) in each of the three classes of pollution tolerant categories was used to help identify the bug. The categories of pollution tolerance are Class 1—bugs least tolerant to pollution, Class 2—bugs moderately tolerant to pollution, and Class 3—bugs pollution tolerant. Sediments and rock were kicked into a large sieve. The sediment and rocks were searched for the different bugs present and the first 30 of those observed were recorded. Since the observation was in the winter, the bugs were not as active, so it was hard to see the slow moving bugs and it took a longer time. ____

Organizing Data

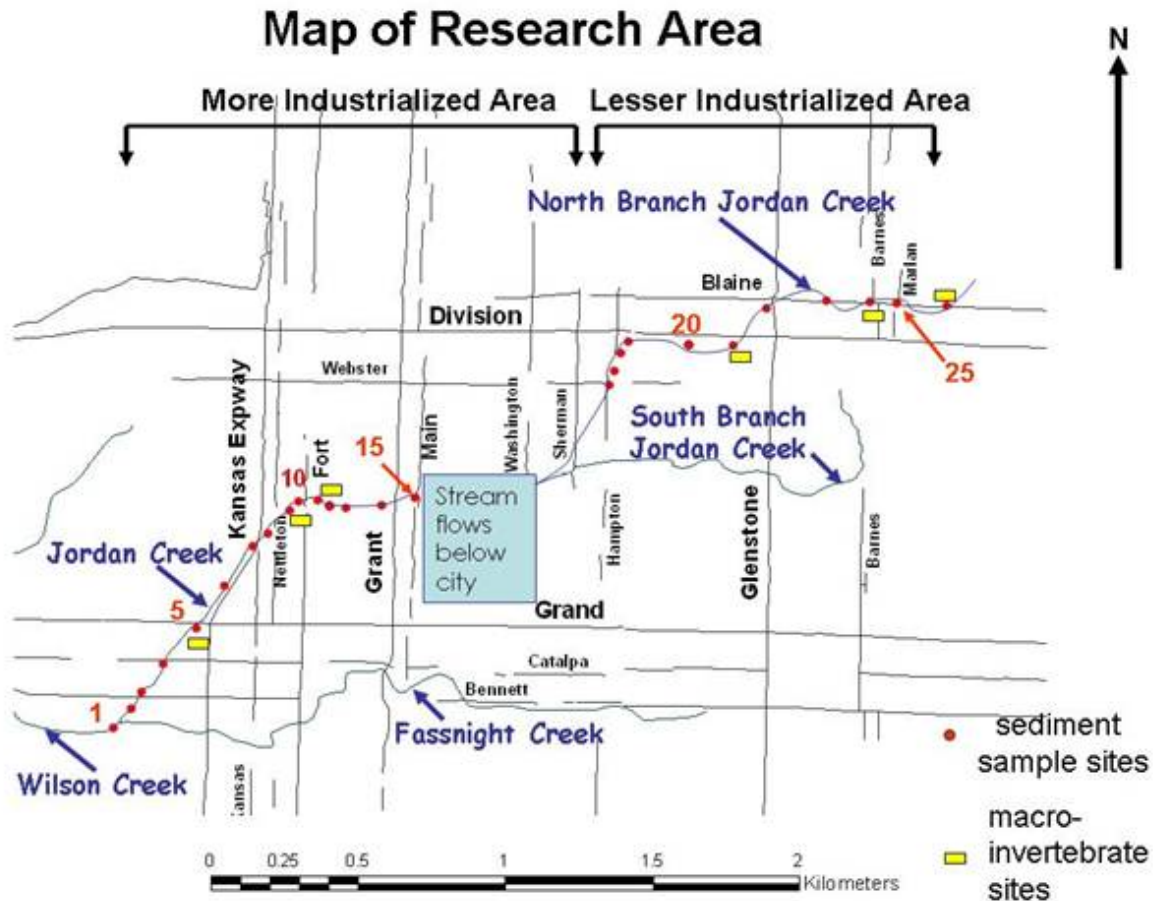
A map was made of the research area using Arc-info and PowerPoint. The sediment sample collection locations and macroinvertebrate study sites in the more and in the less industrialized areas along Jordan Creek

was made. A table summarizing all the data obtained from this research was prepared. Also, a chart of the metal concentrations in the sediments at each collection site along the stream was also made to show the trends of all metal concentrations and the macroinvertebrate study sites. A table showing the detailed results of the macroinvertebrate biodiversity study and stream quality using the Pollution Tolerance Index (P.T.I.) was also made. A Pierson's Correlation chart was made to show the dependence or independence of metal concentrations, pH, and macroinvertebate biodiversity at each sediment collection site (6) where the stream bugs were studied.

The poster board of my research was made for presentation at the St. Agnes Elementary Science Fair and the Ozark Science and Mathematics Regional Science Fair.

RESULTS

The map of my research area showing the sediment collection sites and macroinvertebrate study sites along the Jordan Creek is shown below.



Although sediment stream sediments were collected in cemented channelized and non cemented areas along the stream, the macroinvertebrate were collected in the non cemented channelized (natural channel) areas.

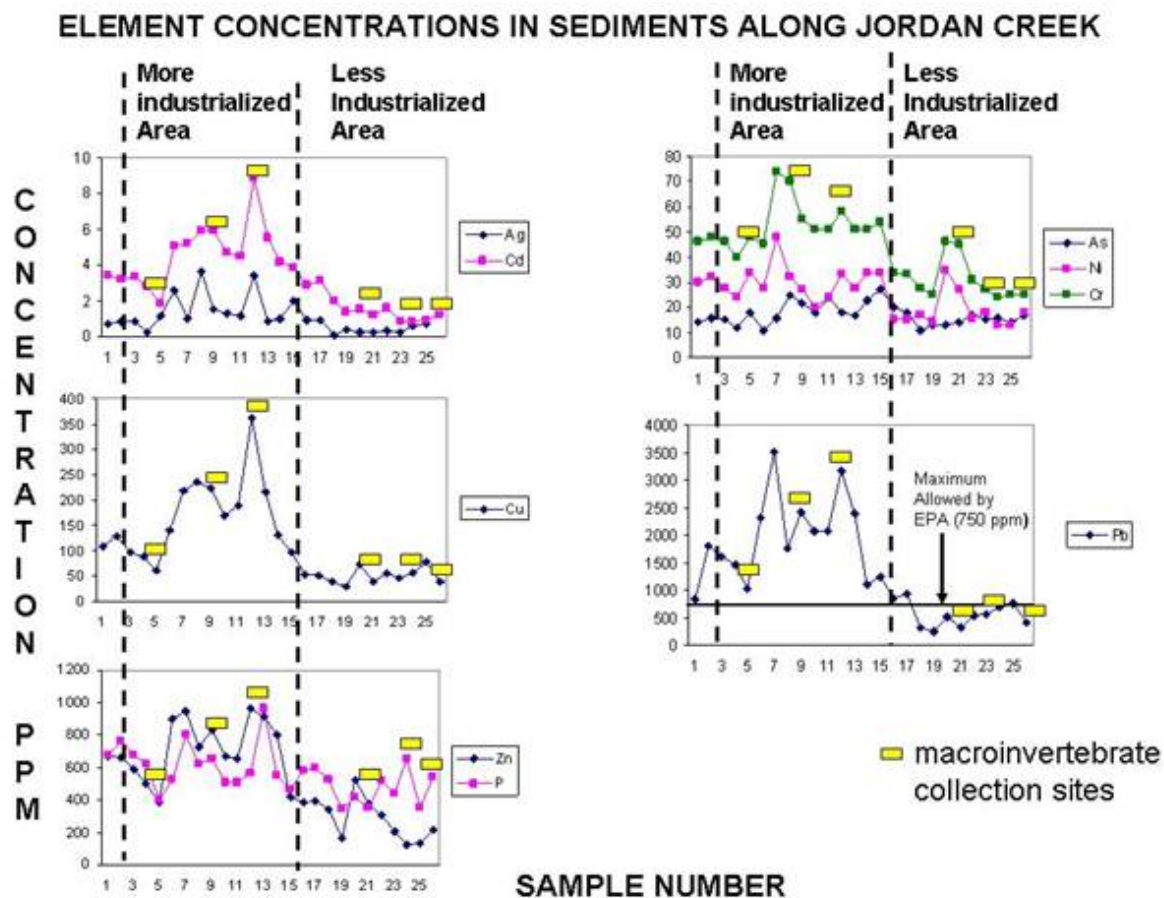
The Data Table is shown below. The table includes the concentration of each element in the sediments along the stream, the mean concentration of each element in both the more industrialized and less industrialized areas along the stream, the pH of the sediment water and the Pollution Tolerance Index of the stream at each of the sediment and macroinvertebrate collection sites.

DATA TABLE

SAMPLE NUMBER	CONCENTRATION OF ELEMENTS IN THE SEDIMENTS IN PPM									SEDIMENT WATER pH	POLLUTION TOLERANCE INDEX USING MACRO-INVERTEBRATES
	As	Ag	Ni	Cr	Zn	P	Cu	Pb	Cd	pH	
MORE INDUSTRIALIZED AREA											
1	14	0.7	30	46	668	674	110	822	3.4	7.4	16 = FAIR QUALITY
2	16	0.8	32	48	660	760	128	1802	3.2	7.3	
3	15	0.8	28	46	588	680	96	1604	3.3	7.3	
4	12	0.2	24	40	502	620	88	1460	2.8	7.2	
5	18	1.1	34	48	380	400	60	1020	1.8	7.4	
6	11	2.6	28	45	900	520	140	2320	5.1	7.3	
7	16	1	48	74	950	802	218	3501	5.2	7.4	9 = POOR QUALITY
8	25	3.6	32	70	723	623	234	1753	5.9	7.4	
9	22	1.5	27	55	832	656	224	2420	5.9	7.5	
10	18	1.3	20	51	671	507	170	2084	4.7	7.3	9 = POOR QUALITY
11	24	1.1	24	51	650	509	190	2078	4.5	7.3	
12	18	3.4	33	58	967	560	361	3176	8.9	7.3	
13	17	0.8	28	51	917	960	215	2395	5.5	7.4	
14	23	1	34	51	804	544	132	1099	4.2	7.4	
15	27	2	34	54	418	465	98	1248	3.9	7.5	
MEAN	18	1.5	30	53	709	619	164	1919	4.6	7.4	
LESS INDUSTRIALIZED AREA											
16	20	0.9	15	34	387	576	53	845	2.9	7.5	16 = FAIR QUALITY
17	18	0.9	15	33	392	593	51	923	3.1	7.2	
18	11	0.1	17	28	340	526	38	326	2	7.5	
19	13	0.4	14	25	162	340	30	240	1.4	7.4	
20	13	0.2	35	46	521	420	72	516	1.5	7.4	
21	14	0.2	27	45	376	350	40	310	1.2	7.3	
22	17	0.3	16	31	298	513	56	526	1.6	7.4	16 = FAIR QUALITY
23	15	0.2	18	27	206	438	45	550	0.8	7.4	
24	16	0.6	13	24	122	653	56	688	0.8	7.3	
25	14	0.7	13	25	130	353	78	746	0.9	7.3	18 = GOOD QUALITY
26	17	0.8	18	25	213	535	40	406	1.2	7.2	
MEAN	15	0.5	18	31	286	482	51	552	1.6	7.4	

The mean concentration of each element in the sediments is higher in the more industrialized area than in the less industrialized area along the stream. The concentrations of Ag, Zn, Cu, Pb and Cd are much higher in the more industrialized area. The pH of the sediment water does not change much along the stream. The Pollution Tolerance Index and quality of the stream at the 6 study sites are shown, but will be discussed later in more detail.

The element concentration trends in the sediments along the stream are shown below.



The elements show a much higher concentration in the sediments in the more industrialized portion of the stream. The macroinvertebrate study sites are also shown on each trend chart. The Pb concentrations in the sediments in industrialized portion of the stream are much higher than allowed by the Environmental Protection Agency according to the Preliminary Remediation Goals (P. R G's). All other elements are below the PRG's. It may be the high concentrations of lead in the sediments which primarily affects the macroinvertebrate biodiversity in my study.

The detailed macroinvertebrate biodiversity study data is shown below.

STREAM QUALITY AT SEDIMENT COLLECTION SITES USING MICROINVERTEBRATE BIODIVERSITY					
SAMPLE SITE NUMBER	SPECIES NAME, (NUMBER OF), AND POLLUTION TOLERANCE: Class--1(least tolerant); Class--2 (moderately); Class 3-(most tolerant) based on first 30 bugs seen		CACULATION OF POLLUTION TOLERANCE INDEX (P.T.I.)	STANDARD FOR P.T.I. VALUES RELATED TO (STREAM QUALITY)	P.T.I. NUMBER AND QUALITY OF STREAM AT COLLECTION SITE
5	gilled snail (7)--1 mayfly larva (4)--1 stonefly larva (3)--1 caddisfly larva (2)--1	clam (6)--2 lunged snail(5)--3 leech (3)--3	4 X 3 =12 1 X 2 = 2 2 X 1 = 2 = 16	#Class1 species X3 #Class 2 species X2 #Class 3 species X1 Sum of product = 23 OR GREATER IS (EXCELLENT) 17- 22 IS (GOOD) 11 - 16 IS (FAIR) 10 OR LESS IS (POOR)	16 = FAIR
9	gilled snail (1)--1 clam (5)--2 aquatic worm (5)--3	midgefly larva(2)--3 lunged snail (7)--3 leech (10)--3	1 X 3 = 3 1 X 2 = 2 4 X 1 = 4 = 9		9 = POOR
12	mayfly larva (2)--1 scud (1)--2 aquatic worm (6)--3	lunged snail (17)--3 blackfly larva (1)--3 leaches (3)--3	1 X 3 = 3 1 X 2 = 2 4 X 1 = 4 = 9		9 = POOR
21	gilled snail (12)--1 mayfly larva (4)--1 stonefly larva (5)--1 caddisfly larva (2)--1	clam (2)-- 2 lunged snail (3)--3 leach (2)--3	4 X 3 = 12 1 X 2 = 2 2 X 1 = 2 = 16		16 = FAIR
24	stonefly larva (4)--1 mayfly larva (3)--1 gilled snail (11)--1 caddisfly larva (2)--1	clam (3)--2 lunged snail (4)--3 leach (3)--3	4 X 3 = 12 1 X 2 = 2 2 X 1 = 2 = 16		16 = FAIR
26	stonefly larva (5) -- 1 mayfly larva (2) -- 1 caddisfly larva (3)--1 gilled snail (11) -- 1	scud (1)--2 crayfish (1)--2 leech (4)--3 lunged snail (3)--3	4 X 3 = 12 2 X 2 = 4 2 X 1 = 2 =18		18 = GOOD

The species and number of species observed at the 6 sediment collection sites are shown, based on the first 30 bugs found. Also, the formula for calculating the P. T. I. and quality of the stream at each site is shown. The results indicate the quality of the stream based on macroinvertebrate biodiversity is related to the concentrations of the elements in the sediments. The higher the concentration of metals in the sediments, the lesser the biodiversity and therefore the poorer the quality of the stream and vice-versa. One sediment collection site (#5) in the more industrialized portion of the stream has a lower concentration of metals similar to the concentrations in the lesser industrialized portions of the stream. This site also indicates a higher water quality as found in the less industrialized area.

The relationship of metal concentrations in the sediments, the pH of sediment water and the number of bugs in each of the three classes of macroinvertebrates is shown in the Correlation Table below.

**CORRELATION OF METALS, pH AND CLASSES OF MACROINVERTEBRATES
(CLASS 1 = LEAST TOLERANT TO POLLUTION; CLASS 2 = MODERATE TOLERATION;
CLASS 3 = POLLUTION TOLERANT) FROM DATA BELOW**

	As	Ag	Ni	Cr	Zn	P	Cu	Pb	Cd	pH	Class1	Class2	Class3
As	1												
Ag	0.463197	1											
Ni	0.289012	0.533935	1										
Cr	0.482286	0.634197	0.897	1									
Zn	0.619001	0.834	0.681339	0.895	1								
P	0.565718	0.308326	-0.47997	-0.15887	0.206868	1							
Cu	0.548943	0.944	0.495532	0.72354	0.935	0.406868	1						
Pb	0.676834	0.923	0.534521	0.758999	0.94	0.442253	0.981	1					
Cd	0.583813	0.937	0.556493	0.77104	0.963	0.353949	0.994	0.981	1				
pH	0.726752	0.130885	0.450493	0.632017	0.49277	0.191057	0.301806	0.455159	0.337301	1			
Class1	-0.821	-0.822	-0.50612	-0.75904	-0.929	-0.49683	-0.919	-0.971	-0.933	-0.60432	1		
Class2	0.522103	-0.25135	0.243864	0.178675	-0.06065	-0.0151	-0.23524	-0.04396	-0.19497	0.764989	-0.12409	1	
Class3	0.721605	0.876	0.460265	0.727402	0.946	0.502338	0.971	0.985	0.976	0.455527	-0.98	-0.07378	1

Sample Number	As	Ag	Ni	Cr	Zn	P	Cu	Pb	Cd	pH	Class1	Class2	Class3
5	18	1.1	34	48	380	400	60	1020	1.8	7.4	16	6	8
9	22	1.5	27	55	832	656	224	2420	5.9	7.5	1	5	24
12	18	3.4	33	58	967	560	361	3176	8.9	7.3	2	1	27
21	14	0.2	27	45	376	350	40	310	1.2	7.3	23	2	5
24	16	0.6	13	24	122	653	56	688	0.8	7.3	20	3	7
26	17	0.8	18	25	213	535	40	406	1.2	7.2	21	2	7

The strong relationships of the macroinvertebrates and the other variables are shown by correlation numbers in red, bold type. There appears to be a strong negative relationship between the number of least tolerant to pollution, class 1 macroinvertebrates living in the sediments and the concentrations of the As (-0.82), Ag (-0.82), Zn (-0.93), Cu (-0.92), Pb (-0.97) and Cd (-0.93) in the sediments. This is expected since the higher the metal concentrations, the lower number of class 1 (intolerant) bugs. Also, there appears to be a strong positive correlation between the pollution tolerant, class 3 bugs and Ag (0.88), Zn (0.95), Cu (0.97), Pb (0.99) and Cd (0.98). This seems to indicate an increase in the tolerant genus of bugs with an increase in heavy metals. This could mean the tolerant bug depends on these metals. The correlation between class 1 and class 3 shows a strong negative correlation (-0.98) which is expected. The low negative and positive correlation numbers of metal concentrations, and pH

related to class 2 bugs indicates the number of bugs in this class are not affected or related to these 2 factors.

There doesn't seem to be a correlation between pH and the concentration of metals and number of bugs in the sediment. There is a strong relationship between some of the metal concentrations shown in bold black type. As mentioned before, there were many former facilities built along the Jordan Creek and some still present which could have emitted these metals into the stream and formed in the sediments.

CONCLUSIONS

The data obtained in this research seems to agree with my hypothesis. The concentration of heavy metals was higher in the stream sediments along Jordan Creek in the more industrialized area compared to the less industrialized area. Also, the biodiversity of macroinvertebrates in the sediments was smaller in the sediments which contained higher concentrations of heavy metals, and larger biodiversity in the sediments which contained smaller concentrations of heavy metals. Using the Pollution Tolerance Index and the information above, the quality of the stream at different locations was determined.

ACKNOWLEDGEMENTS

I wish to thank my science teacher, Miss Lynn Vogel and my father who encouraged me to do this project. I wish to thank the Geology and Chemistry Departments for allowing me to use their facilities.

