INTRODUCTION

Introduction

The most visible water monitoring program in Anchorage is the Anchorage Waterways Council's (AWC) Citizen Environmental Monitoring Program. This program is the only comprehensive freshwater monitoring program in Anchorage (AWC 2002). Since 1998, more than 100 volunteer monitors have participated in the program collecting data from 25 sites across the Municipality of Anchorage from Eagle River to Girdwood (AWC 2002a, Evans-Dinneen 2003). All volunteers are trained under the Quality Assurance/Quality Control Plan approved by the Environmental Protection Agency in 2002. Under this plan, volunteers collect data for temperature, turbidity, pH, conductivity, total dissolved solids, ortho-phosphate, nitrate-nitrogen, coliform bacteria, and dissolved oxygen (AWC 2002a).

Starting in May 2003 Alaska Pacific University (APU) under a grant from University of Alaska's BRIN program teamed with the Anchorage Waterways Council (AWC) to evaluate the AWC's Quality Assurance Project Plan. The goal was to check 10% of the data collected by the citizen monitors in order to assess the accuracy and precision of the data. Richard Myers, Professor of Environmental Science, led the project assisted by Shayla Swedlund, a graduate student in APU's Master of Environmental Science program, and Melissa Mayer, a senior environmental science major. The research examined paired differences on data obtained by AWC volunteers and the APU team for each parameter. Additionally, a quality control session was conducted to assess the accuracy and precision of the volunteers' data when compared to standard solutions.

Methods

Replicate (parallel) analysis was performed at selected sites during summer sampling events that occurred from May to August on the second and last Sunday of each month. Beginning June 8, 2003, three or four sites were chosen on a specific Sunday and the volunteers were contacted to arrange parallel sampling. Parallel sampling entailed APU team members and AWC volunteers performing identical analyses at the AWC volunteer site during a regularly schedule sampling event. Samples were collected at the same time and both AWC and APU personnel conducted tests simultaneously.

Additional evaluation occurred at a quality control session in APU's chemistry lab on September 23, 2003. All monitors who needed to be recertified were invited. Measured samples and standards for each monitored parameter were prepared and measured using a Hach DR4000 spectrometer, Hach turbidity meter, and YSI model 95 oxygen meter. Each volunteer analyzed the samples using the AWC methods. A third component of our evaluation was a survey sent to all AWC volunteers for an opportunity to identify the strengths and weaknesses of the citizen monitoring program.

Statistical analysis was performed using SPSS 12.0 for Windows. Normality was checked using the K-S test for normality. When normality assumptions were met, paired-samples t-tests were conducted. Non-normal data were analyzed with the Wilcoxon Signed Ranks test (Field 2001). Accuracy was calculated by taking the mean of the concentrations measured at the quality control session and subtracting it by the true value. Precision was determined by the standard deviation of the data from the quality control session (USEPA 1990).

Replicate Sampling Results

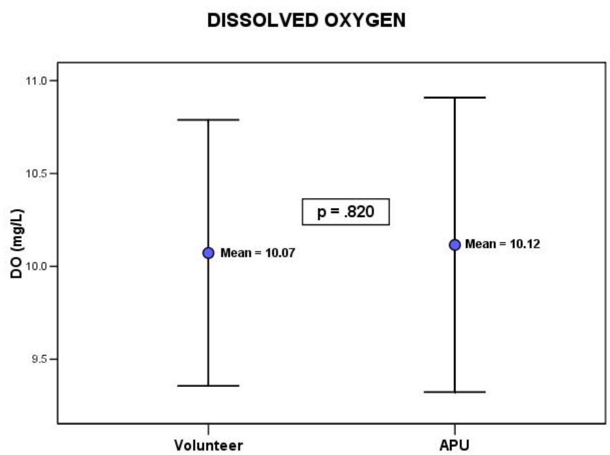
Replicate (paired) sampling occurred on 17 different events from the period of June to October 2003. Data for selected parameters the AWC's program measures were collected independently at the same time by both the AWC volunteers and the APU team. Strictly speaking, chemical and biological tests were analyzed. Temperature, physical environment, and weather conditions are also measured by the volunteers, but were not included in this analysis. Each parameter examined is discussed below and a summary of the results of replicate (paired) sampling is presented in Table 1. Table 1 presents the results of paired sampling in terms of the mean difference. A paired difference is

Table 1. Mean Difference (Volunteer – APU)

Parameter	**n**	**Mean Difference**
Turbidity	14	0.500*
pH	13	0.100
Conductivity	13	-28.9**
Hanna pH	13	-0.19*
TDS	13	-14.2**
Dissolved Oxygen	13	-0.04
Phosphate	16	-0.04
Nitrate	16	0.41
E coli 1 mL	10	- 50 cfu
E coli 5 mL	10	516 cfu
Total coliforms 1 mL	10	-250 cfu
Total coliforms 1 mL	10	-422 cfu
* $p < 0.05$ ** $p < 0.001$		

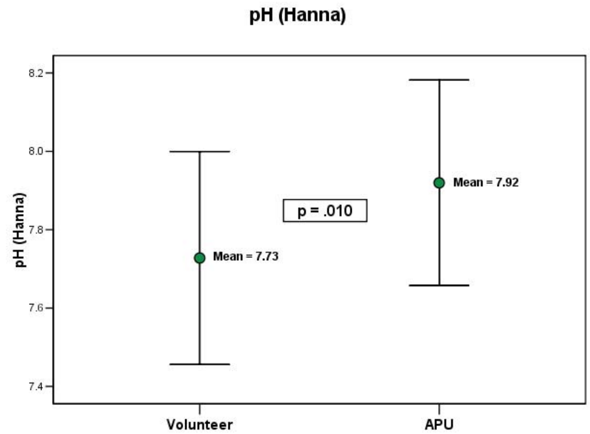
computed by taking each AWC measurement minus the corresponding APU measurement for a parameter. For example, if the AWC volunteer measured a pH of 7.0 and the APU researcher measured 6.7, then the paired difference would be 0.3. The mean of all paired differences for a parameter measured over the summer is the mean difference. It should be noted that even though 17 sampling events took place over the summer of 2003, the sample size varied from 10 to 16. This was due to missing data from faulty equipment, errant readings, etc.

The dissolved oxygen test was a form of the Winkler titration method contained in the LaMotte's Shallow Water Monitoring Kit (Code: 5854-01). The data for the AWC volunteers and APU team met the assumptions of normality. The mean difference between the AWC and APU was 0.04 ppm (t = 0.23, p = 0.82). During two sampling events,

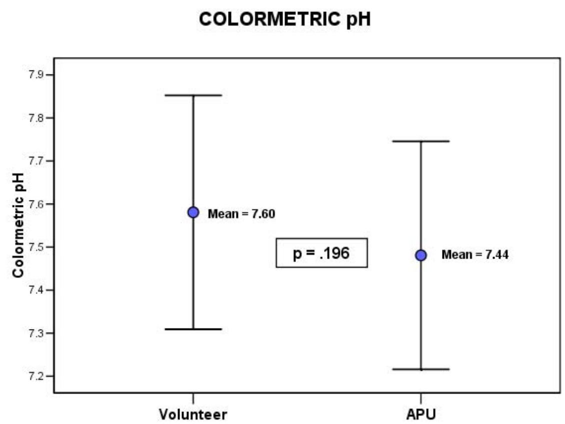


AWC volunteers measured excessively high concentrations of dissolved oxygen. These were 2.1 and 3.0 ppm higher than if the water was 100% saturation. However, in one of these instances, the APU team also measured a higher than 100% saturation concentration at the site indicating either a flaw in the method or supersaturation conditions, due possibly to excessive photosynthesis.

Turbidity was measured using the LaMotte Shallow Water Monitoring Kit's (Code: 5854-01) turbidity columns. In replicate sampling, the mean difference was 0.50 JTU. There was a statistically significant difference (t = 2.9, p = 0.013) and a statistically significant correlation between the two data sets (r = 0.62, p = 0.018). While the difference in turbidity was 0.50 JTU units higher for volunteers and this was statistically significant, the actual values are only marginally different. That is, it is felt that the difference in turbidity is not of practical significance.



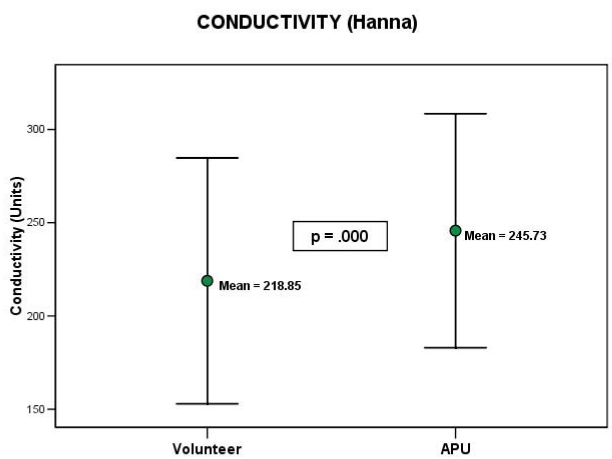
The pH was tested by AWC volunteers using two methods: LaMotte's Shallow Water Monitoring kit's (Code: 5854-01) color comparator and the Hanna Combo Meter. The AWC volunteers measured a mean of 7.6 (standard deviation 0.45) using the color comparator and the APU team data had a mean of 7.5 (standard deviation 0.44).



The mean difference between pH reading was only 0.10. Hence, there was no difference between the two groups. ($Z = -1.29$, $p = 0.20$). There was a significant correlation between data sets ($r = 0.79$, $p = 0.001$).

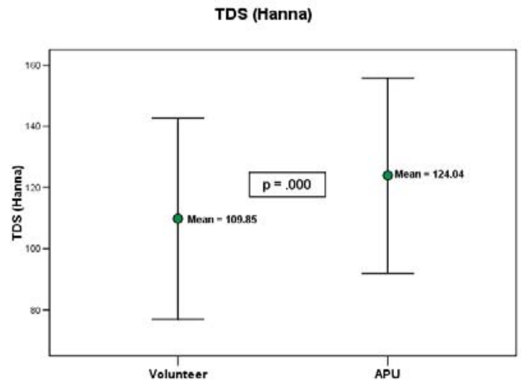
Unlike the color comparator, the Hanna Combo Meter measured statistically significant differences in pH between the volunteer and intern instruments. The mean difference was 0.19 ($t = 3.07$, $p = 0.01$). The APU Hanna meters tended to measure higher concentrations (AWC mean = 7.73, standard deviation 0.49; APU mean = 7.92, standard deviation 0.47). There was a significant correlation between the two ($r = 0.89$, $p < 0.001$). While the mean paired difference between the two measurements was 0.19, the practical difference between AWC and APU measurements is questionable. On six trials, the interns used two Hanna meters and tested them side-by-side in the same bucket to explore the variability of the instruments. There was a significant mean difference between the two APU instruments of 0.12 (t = 3.26, p = 0.02).

There was reasonable agreement when comparing the two pH methods (AWC: Z = -1.70, p = 0.09; APU: Z = -3.52, p < 0.001). The APU Hanna meters measured nearly 0.5 higher than the color comparator, while the AWC color comparators had a closer relationship with the Hanna meters, the latter measuring only 0.1 higher.



Conductivity is also collected using the Hanna Combo Meter. The mean difference in conductivity readings between the paired data was 28.9 µs/cm (t =5.3, p<0.001). Similar to pH, the AWC Hanna meters measured significantly lower concentrations than the APU Hanna meters with means of 218.85 µs/cm (standard deviation 118.80 µs/cm) and 245.73 µs/cm (standard deviation 113.12 µs/cm), respectively. The correlation between the two groups was very high (r = 0.99, p < 0.001). Further testing of the variability of the two APU Hanna meters produced a statistically significant mean difference of 20.67 µs/cm (t = 5.78, p = 0.002).

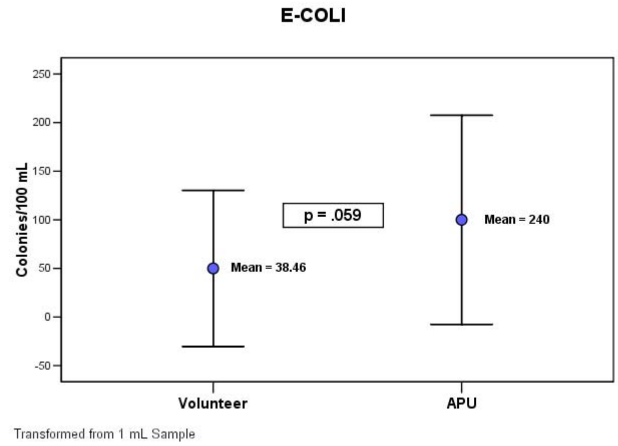
Total dissolved solids was the third parameter measured with the Hanna Combo Meter. This parameter also displayed significant differences between the AWC volunteers and APU team with means of 109.85 ppm (standard deviation 59.15 ppm) and 124.04 ppm (standard deviation 57.52 ppm), respectively (t = -5.82, p < 0.001). The correlation between the two groups was again very high (r = 0.99, p < 0.001). Similar to the other two parameters measured with the Hanna meter, the APU team measured higher concentrations of total dissolved solids and had significant variability of 12.33 ppm between the two APU instruments (t = 5.81, p = 0.002). The mean difference between AWC and APU total dissolved solids was 14.2 ppm (t=5.8, p<0.001).



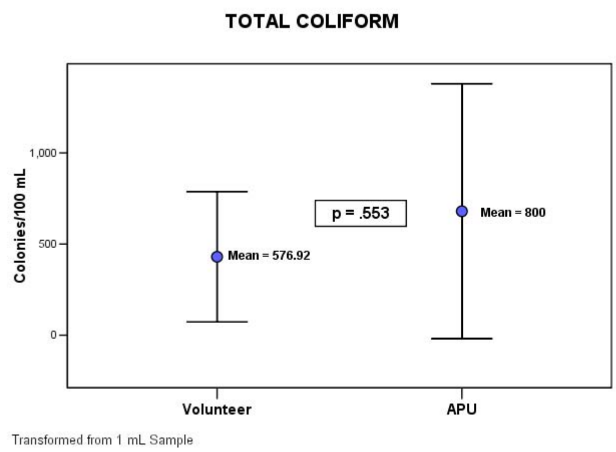
Ortho-phosphate was measured with the Hach Ortho-Phosphate kit (Model: PO-19). The mean difference in paired ortho-phosphate data was 0.04 ppm (z = 0.668 ppm, p = 0.504). There was a significant correlation between the two (r = 0.62, p = 0.018). Nonparametric statistics had to be used because of the many values of 0 ppm recorded with this kit. For both the AWC and APU groups seven of the 16 values were recorded as 0 ppm causing highly skewed data. The non-significant difference is difficult to interpret since a large number of the data were zero values and the other values recorded were generally below the detection limit for phosphate using the Hach kit.

Nitrate-nitrogen was tested using LaMotte's Nitrate-Nitrogen kit (Code: 3354). Similar to the ortho-phosphate kit, there were many recorded values of 0 ppm with 10 of the 16 values from the AWC group and 13 of the 16 from the APU team. Again, it is not possible to draw meaningful conclusions with so many zero values recorded.

Coliform bacteria were measured using the Coliscan® pour-plate method which detects for total coliforms and *E.coli*. Each recorded value was multiplied to indicate the number of colony forming units per 100 mL of sample water. *E.coli* was tested using two volumes: 1 mL and 5 mL. For the 1 mL sample, the AWC counted 50 cfu (standard deviation 127 cfu) while the APU counted 100 cfu (standard deviation 170 cfu). The difference in *E coli* counts was not statistically significant (Z = 1.89, p = 0.059). For the 5 mL sample, the AWC counts were higher than the APU team with a mean difference of 516 cfu (z = 1.9, p= 0.059). Once again, this was not statistically significant (Z = 1.89, p = 0.059). When analyzing if there is a difference between the counts obtained between the two volumes, there was a statistically significant difference for the AWC volunteers (Z = 2.85, p = 0.004), but not for the APU team (Z = 0.83, p = 0.41).



Total coliform counts were consistently higher for the APU team than for the AWC volunteers for both volumes. The mean colony forming units counted by the AWC volunteers for 1 mL was 430 cfu (standard deviation 566 cfu) while the APU team counted 680 cfu (standard deviation 1106 cfu). There was no statistically significant difference between the paired counts for the 1 mL volume (Z = -0.59, p = 0.55). Likewise, the 5 mL volume obtained means of 656 cfu (standard deviation 1218



cfu) for the AWC volunteers and 1,078 cfu (standard deviation 2872 cfu) for the APU team. The mean difference was not statistically significant ($Z = -0.36$, $p = 0.72$). There was also no significant difference between the volumes used for counting total coliforms for both the AWC volunteers and APU team, respectively ($Z = -0.98$, $p = 0.33$) ($Z = -0.94$, $p = 0.35$).

Quality Control Session

On September 23, 2003, recertification training was held at Alaska Pacific University's chemistry lab. Ten volunteer monitors attended, four of whom were new monitors finishing their training. Volunteers tested the known standards using their test equipment. Standard solutions and water samples analyzed using APU instruments were given to the volunteers to analyze.

Dissolved oxygen was measured by each of the nine volunteers three times for a total of 25 replicate samples (there were 27 individual measurements on the same sample, but two were discarded). The volunteer mean concentration of dissolved oxygen in the sample was 8.5 ppm while the concentration using the calibrated YSI Model 75 dissolved oxygen meter was 9.1 ppm. The accuracy of the volunteer method was -0.6 ppm, just shy of the data quality objective of ±0.3 outlined in the AWC QAPP. The precision of the volunteer method at 0.78 ppm did meet the data quality objective of ±0.9 ppm.

Turbidity was measured by each AWC volunteer once for nine replicate samples. The AWC mean turbidity was 5.0 JTU, which was very close to the standard, which was determined as 4.1 JTU using a calibrated Hach pocket turbidimeter. The accuracy was determined to be within acceptable limits of the quality objective which was set at ±3. The accuracy of the volunteer turbidity method was 0.9. The volunteer method also met the quality objective of precision (±3) where every volunteer recorded the same concentration, yielding a standard deviation of 0.00.

The pH using the color comparator was measured by each volunteer twice resulting in 14 replicate samples. The AWC volunteer mean pH was 7.6 and the standard solution pH was 7.0 . Thus, the accuracy was calculated to be 0.6, 0.2 higher than the acceptable limit for this method. The pH method did meet the data quality objectives for precision with 0.14 (acceptable = ±0.6).

The Hanna Combo Meter was used to measure pH, conductivity, and total dissolved solids. AWC volunteers took triplicate measurements for each parameter for a total of 22 replicate samples. The mean volunteer pH was measured to be 7.5 with the standard pH measuring at 7.0. The accuracy was 0.5 which was short of the objective of ±0.2 set by the AWC. The method was precise at 0.19, which barely made the quality objective of ±0.2. Conductivity had a measured mean of 299.6 μs/cm for the AWC volunteers while the standard measured was 306.8 μs/cm. These data do not meet the data quality objectives for precision with the actual precision measuring at 141.58 μs/cm (data quality objective ±0.5 μm). Conductivity did meet the accuracy objective at 7.20 μs/cm (data quality objective ±20 μm). Total Dissolved Solids met neither the accuracy nor the precision data quality objectives with the measured precision value of 16.68 ppm (data quality objective ±2 ppm) and a measured accuracy value of 16.00 ppm (data quality objective ±2 ppm).

Table 2. AWC Quality Assurance Project Plan's Data Quality Objectives

	Precision Objective As outlined in the QAPP	Precision Actual Standard Deviation	Accuracy Objective As outlined in the QAPP	Accuracy Actual Mean - Actual
Dissolved Oxygen	±0.9 ppm	0.78	±0.3 ppm	-0.60
Turbidity	±3 JTU	0.00	±3 JTU	0.90
pH (color comparator)	±0.6 units	0.14	±0.4 units	0.60
pH (Hanna)	±0.2 units	0.19	±0.2 units	0.50
Conductivity	±0.5 µs/cm	141.58	±20 µs/cm	-7.20
Total Dissolved Solids	±2 ppm	16.68	±2 ppm	16.00
Ortho-Phosphate	±0.5 ppm	0.27	±0.5 ppm	-1.17
Nitrate-Nitrogen	±0.5 ppm	1.53	±0.5 ppm	-1.40

Discussion

Participation is one of the issues that arose when collecting data for the parallel study. As the summer progressed, there was less cooperation when scheduling sampling with the AWC volunteers. The AWC Quality Assurance Project Plan (QAPP) recommends that ideally volunteers sample at 2 p.m. on the second and last Sunday of every month from May to August or the second Sunday of every month from September through April. If volunteers are unable to sample at the ideal time, they should either make an effort to sample between 11:00-7:00 on the designated Sunday or contact the AWC Monitoring Director to have someone fill in for that day. Of the 17 sampling events, 6 were neither sampled in that time frame nor on the given Sunday. Seven were sampled on the designated Sunday, and only four were sampled on the Sunday at 2 p.m. In many conversations, volunteers indicated their frustration that sampling must occur on Sundays in the middle of the afternoon. During the summer many volunteers take advantage of the weekends to leave town for recreation. However, they soon become frustrated that they must stay home over the weekend or they decide to sample on another day when they are in town. Hence, a consistent sampling schedule is not followed by all

AWC volunteer monitors, and the inconveniences on the volunteers may have implications for monitor turnover. Consistency is important in science and may be an issue the AWC should emphasize to volunteers at the training sessions before volunteers decide to make the time commitment.

Inconsistency in data was evident in certain volunteer methods. The Hanna Combo Meter showed significant differences between instruments for all three parameters it measures: conductivity, total dissolved solids, and pH. For accuracy, total dissolved solids was the only parameter that met the objective while pH and conductivity did not meet the objectives. For precision, conductivity and total dissolved solids failed the objectives, while pH did meet the objective. Thus, there was not one parameter that proved to be both accurate and precise. An evaluation of whether this instrument acquires useful information should be conducted to determine whether to continue to utilize this instrument.

On many occasions volunteers speculated that the measurement their Hanna meter was recording was not normal for their site. Fortunately, many volunteers would realize the flaw immediately and would mention the issues to the AWC Volunteer Director. They would then have to wait weeks or even months until the damaged meter was returned for repair and a replacement was received by the volunteer. Several sampling events would be lost in the course of replacing the instrument. Unfortunately, the meters would usually not last more than six months until something went wrong and volunteers would be in the position of waiting for a replacement instrument to continue to collect the three parameters. Thus, depending on how valuable the AWC feels conductivity, total dissolved solids, and pH are to collecting baseline data, it would be important for them to consider another more reliable instrument to replace the Hanna Combo Meter.

Perhaps, what can be seen as the best investment of the AWC's funds for the program is the LaMotte Shallow Water Monitoring Kit which contains the tests for dissolved oxygen, turbidity, and pH. All three fit the data objectives of accuracy and precision for the Quality Assurance Project Plan. However, the turbidity test did show slight differences in the parallel sampling. This could possibly be caused by misunderstanding of new volunteers who may not understand the procedure thoroughly. Some may question whether you consider the number of drops to be the number it takes before the vial became cloudier than the sample. Some volunteers may also believe a drop of starch equals 1 JTU instead of equating the contents to the mark on the starch dropper to 1 JTU. Certainly, if the AWC is able to check through the data sheets right after the sheets are dropped off at the office, there would be more chance of correcting the error before too much time is lost collecting inaccurate data.

The dissolved oxygen method proved to be one that caused concern by volunteers in the quality control session. Some struggled with the issue of introducing bubbles to the bottles while filling with the sample. This would result in inaccurate data. This could be a possible reason why the data using the method did not meet data quality objectives for accuracy. However, the dissolved oxygen method did produce precise data in the quality control session. This implies that the volunteers are all performing the test in the same manner. It is helpful that the AWC's data sheets require the volunteers to test dissolved oxygen three times. If there is a difference between any two readings greater than 0.6 ppm, then the volunteers must repeat the steps again with three new samples.

However, on one occasion a volunteer tested the dissolved oxygen at the site and measured an amount much higher than that the APU team measured. Later, when referring to oxygen saturation tables, it was evident that given the air pressure and temperature of the water, the measured concentration of dissolved oxygen was above 100% saturated. A good practice would be for the Volunteer Director to have a copy of the dissolved oxygen saturation table nearby when checking the volunteer data sheets for completeness or anything that would be out of the ordinary. Likewise, each volunteer should have an understanding of what would be the value of dissolved oxygen at 100% saturation at the given temperature and air pressure so they can be on the alert for anomalously high values.

The pH method included in the LaMotte Shallow Water Monitoring Kit proved to mirror the Hanna pH's ability. The color comparator pH was not accurate as it tended to be higher than the actual standard; however it met the objectives for precision. Since pH is an important parameter to measure in water bodies, if the AWC does decide to phase out the Hanna Combo Meters, they should continue to monitor pH. However, it would not be recommended to rely on this method as the sole means to measure pH. Because it does rely on color comparison by volunteers, there is some of subjectivity in the method.

Another color comparator method is the ortho-phosphate kit. There was no significant difference in the parallel study. It was also deemed inaccurate, but precise given the data quality objectives outlined by the AWC. This could be a result of the many values of zero measured by both the AWC volunteers and the APU team. Volunteers seven times recorded concentrations of 0 ppm out of the 16 parallel sampling times. The APU team measured 0 ppm on 11 out of the 21 sampling events.

Unfortunately, ortho-phosphate is a naturally occurring substance in natural water, yet is undetected in the streams monitored by the AWC. At the quality control session, variability in how volunteers treat the sample was discussed. The sample with reagent is to be swirled and allowed to rest for eight minutes. A gentle swirling method is recommended by Hach, however the volunteer could either not swirl it hard enough or shake it vigorously and impact the reaction. In addition, if the volunteers are doing more than one test at a time, they may let color development go beyond the eight recommended minutes and read the value at a higher level than actual. Both issues have implications for inaccurate measurements for water quality.

The biggest issue concern the phosphate test is the lack of sensitivity using the phosphate kits. Data from the USGS indicates that dissolved ortho-phosphate values are well below the detection limits of the kit used by AWC volunteers (Glass, 1999). One of the author's of this report examined this issue in detail and one recommendation from her study was for the AWC to switch to an instrument that is able to detect low levels of this nutrient or find an alternate method that does not rely on the color subjective nature of humans (Swedlund, 2004).

Likewise, nitrate-nitrogen did not have statistically significant differences in the parallel study. However, it was neither accurate nor precise given the data objective guidelines. The volunteer kit did not measure any nitrate-nitrogen for more than 50% of the sampling times. The volunteers recorded 0 ppm on 10 of the 16 returned data sheets and the APU team recorded zero on 17 of the 21 times it sampled for nitrate.

Bacteria are a ubiquitous parameter. Despite that, there was no statistically significant differences of the means 1 mL and 5 mL samples for both *E.coli* and total coliforms. The method the AWC uses to enumerate coliform bacteria is convenient for volunteers and does not require sterile lab conditions. However, it does expect the volunteers to keep their homemade incubators at a constant temperature over the course of incubation. The homemade incubators consist of cardboard boxes, a 40-watt light bulb, a thermometer, and flaps cut into the box for temperature adjustment. Over the course of the study, several issues with the coliform bacteria method surfaced. One was the issue of storage of the Coliscan® medium. Before the quality control session, the volunteers were trained to store the medium in the refrigerator until use. Often they would receive several months worth of medium at a time. When the company that makes the Coliscan® medium was contacted after the quality control session, they emphasized the need for the medium to be kept frozen. If absolutely necessary, the volunteers can refrigerate the medium for up to three weeks. It was also recommended by that medium not be used after six months. Traditionally, the medium was mass ordered by the AWC, stored in a refrigerator, and distributed to volunteers in amounts to cover a volunteer's need for months. The result was that the colonies of bacteria had a slightly different coloration. *E.coli* would be more teal and might be counted by volunteers as the unknown teal colony instead of *E.coli*. The total coliforms which would range from light pink to fuchsia would become lighter with improper storage or expiration. Thus, the total coliforms that would be a light pink for good medium would be white and as a result not counted as a coliform by volunteers. The method of how to count colonies was also an issue of concern for volunteers at the quality control session. Volunteers questioned how large a colony should be in order to be counted. Some did not count colonies that were the size of a pin head, some did. Micrology recommends that colonies be counted regardless of the size of the dot in the medium. There were also many questions raised at the quality control session about determining the color of the colony and where it fits in with the classification. In all, there are many questions about the interpretation of the colonies so it would be recommended to have samples taken to a licensed lab for verification.

The Coliscan® method is used to collect baseline data on bacteria for the Anchorage streams. AWC monitors seven streams that are on the list of EPA 303(d) impaired streams for fecal coliform contamination. However, the Coliscan® method only measures one form of fecal coliform, *E.coli*. The total coliforms are not essential in understanding the extent of fecal coliform contamination in the water. The AWC should consider if it is necessary to have the volunteers count the total coliforms if it is not required for baseline data on fecal bacteria on the impaired streams. Either a different method should be used which detects all fecal coliform bacteria or a split sample should be taken to a certified laboratory to collect this valuable data for the impaired streams.

Survey

The monitors for the AWC tend to be very conscientious with the sampling efforts out in the field. They all volunteer their weekends and extra hours in training to collect data that they see as necessary to understanding the creeks and streams that are in their backyard. A survey was sent out to all the volunteer stream monitors for the AWC immediately after the quality control session in September 2003. The reason for the timing was that the volunteers had just finished monitoring two times every month for the summer and would have concerns and issues clearly in mind. The survey was sent out to acquire information about the volunteers: their residence, education, occupation, and inspiration to become a volunteer stream monitor. A separate section asked about sampling times and test methods. There was also space at the end of the questionnaire to learn about what the volunteers view as the positive and negative aspects of the program.

The majority of those who returned the surveys were educated residents of the Municipality of Anchorage and range from students to environmental specialists to retired military personnel. Most got involved in the program because they lived nearby a stream and became interested that way. One volunteer wrote, "I walk by the creek I monitor almost daily. I have always been interested in the quality and restoration." Another recognized the personal benefit of volunteering. You "feel you are doing something concrete for the streams in Anchorage." Others just wanted to volunteer for an organization. All recognize at least one positive impact the AWC program has on the community. In July 2003 the Alaska Department of Environmental Conservation cut funding of some volunteer monitoring programs in Alaska. Since then, the benefits of the program have become increasingly apparent. One volunteer wrote, "the constant monitoring will find contaminants before too much harm is done. The baseline data will also be a reference for years to come." Another volunteer recognized the economic impact. "It allows our city to monitor its creeks with far less funds than if a paid city worker was doing the monitoring." The volunteers definitely serve as citizen advocates for the local water bodies in the Municipality of Anchorage.

The volunteers also indicated concerns about the program. Finding time to sample at the designated sampling time was near the top of the list. Some (43%) of those who returned the survey said they sometimes sample at the designated Sunday at 2 p.m., while the rest always sample at the preferred time. Conflicting work schedules, inclement weather, and frozen sampling site were other conflicts raised by volunteers. AWC volunteers also indicated concern about results obtained by sampling tests. The Coliscan® method topped the list of questionable methods followed by dissolved oxygen and parameters measured using the Hanna Combo Meter. Turbidity and nitrate-nitrogen were also recognized as parameters of concern. In the open-ended question about negative aspects of the program, volunteers raised a variety of issues. The most common concern was the quality of the test equipment and the reliability of the data obtained using the current methods. One volunteer suggested the AWC look into purchasing a more reliable nutrient test method, one that can detect low levels of the nutrient. Another volunteer suggested expanding the program to include additional tests for metals and other nutrients. This could be done if the AWC would invest in a spectrometer or colorimeter and have the volunteers bring their sample to the office to test. The other concern raised was of the time commitment necessary to become a volunteer. Some volunteers felt as though the time commitment needed for the program was not addressed in the training to become a stream monitor. Often in summer they are anxious to go out of town or do other recreational activities and feel pressured to stay to sample. In lieu of the most recent loss of volunteer monitors, it would be important for the AWC to address these issues in the training and Quality Assurance Project Plan revisions to ensure continual sampling across the municipality.

Conclusion and Recommendations

The Anchorage Waterways Council's Citizen Environmental Monitoring Program has many beneficial aspects. The volunteers serve as citizen advocates, important baseline data collectors, and concern members of the community. However, to make the most use of the limited resources available by the AWC, some changes should be considered to ensure the program's future success.

1. Training: When training volunteers for the first time, emphasize the time commitment necessary to collect consistent baseline data. This should reduce turnover and ensure that dedicated volunteers stay with the program.

2. Hanna Combo Meter: Look into buying new instruments to conduct the total dissolved solids, conductivity, and pH tests. The Hanna Meter has a high degree of variability and can be used for a short time before needing to be replaced.

3. Nutrient parameters: There is a lot of confusion with volunteers about the necessary method of mixing the reagent and sample. Sample processing time and mixing method can both impact the color development and result in inaccurate data. There are many zero values measured using both nitrate-nitrogen and ortho-phosphate methods while there is potential that there are concentrations of the nutrient in the water. More sensitive test methods or instruments with lower detection limits should be considered to replace the existing methods or determine the normal concentration for each individual site. Alternatively, nutrients can be processed at a central location similar to a system that Cook Inlet Keepers have adopted in Homer.

4. Coliscan® medium: Better training needs to be conducted on how to read the bacteria colonies. For fecal coliform impaired streams, a method that detects fecal coliforms, not just *E.coli*, may be an alternate method to collect more useful data for these EPA 303(d) impaired water bodies.

It must be emphasized that the volunteers are mostly dedicated community members who want to contribute to the well being of environment. Those who are volunteers are conscientious and dedicate many hours every month to collect potentially valuable information on the state of the water in the Municipality of Anchorage. The value of this water quality data depends on the quality of the test methods used to measure each parameter. With inaccurate methods come inaccurate results. To make the most of the resources available to the AWC, they must evaluate the citizen program to ensure that the time spent by the volunteers is time well spent.

LITERATURE CITED

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