WATER QUALITY ASSESSMENT OF MAJOR RIVER SYSTEMS IN BENGUET PROVINCE, PHILIPPINES

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Abstract: The water quality of rivers in Benguet Province was determined in terms of physical and chemical parameters as part of the effort to characterize the freshwater habitat of indigenous fishes and shells in the province. This was also done to determine the status of rivers despite pressures from vegetable farming, residential and mining activities. A total of 12 rivers were purposely sampled to represent all the municipalities in the province. In terms of physical parameters, the rivers generally have cold temperature, rocky sandy substratum, shallow depth, full light penetration and fast flow (except Ambuklao Dam). The low temperatures of the rivers coupled with the shallow depths and fast flow of the rivers have contributed to the low biodiversity and low productivity of these water bodies. On the other hand, the pH, dissolved oxygen, nitrate, ammonia and phosphate contents of these rivers are mostly within the water quality criteria set in DAO 34 series of 1990. Thus, it could be concluded from these data that despite the pressures from vegetable farming, residential and mining activities, major river systems in Benguet are still clean. It was noted that synthetic input from vegetable farming mostly affects these rivers. Moreover, the chemical characteristics of these rivers are within the optimum range for aquaculture. These water qualities need to be considered as guidelines to be met when culturing indigenous fish and shell species.

Keywords: river systems, water quality assessment

Introduction:

Being the ‘ceiling’ of Luzon, Benguet Province is home to various major river systems in northern part of the island. Its powerful rivers have been tapped as power resource base since 1950s which saw the construction of Ambuklao and Binga Dams. Records of the Provincial Veterinary Office (PVO 2002) showed that the province has an approximate area of 2,490 hectares of inland waters, about 64% is from Ambuklao, Binga and San Roque Dams and the remaining 36% is from rivers, lakes, springs, creeks and small farm reservoir and impoundment projects.

The aquatic ecosystems of the province were once pristine, endowed with various indigenous fish, shell and related species as well as edible plants. However, these aquatic resources have not been given much emphasis in the field of research and development simply because they are not a major industry in the province compared to agriculture. But with the turn of events on the ever dwindling

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land available for agriculture, increasing population and the lack of protein food source, there is a need to develop and revive traditional culture systems most especially in aquatic resources food production.

With the economic pressure and other forces coming into play, the major river systems of the province have been stagnated with wastewater, or have been redirected to accommodate hydropower projects. Moreover, pollution of aquatic habitats from agricultural run-off and mining activities as well as the introduction of exotic species has threatened these ecosystems and the indigenous inhabitants which are now on the brink of extinction. Thus, there is a need to protect these rivers from further degradation. Further, there is a need to sustain and conserve the aquatic resources in-situ and ex-situ through aquaculture.

Imperative to any management of aquatic ecosystem or aquaculture venture is first the need to assess the state (water quality) of the freshwater ecosystems. This means monitoring the water quality with the existing water quality standards. For example, Upper Agno and Upper Amburayan River are listed as Class A and B as of 1995, respectively. However, these are expected to have changed as degradation activities have proliferated during the past decade. Moreover, ecological factors affecting the biology of fish and shells in their natural habitat are essential in order to ascertain the success of any ex-situ conservation and propagation. Mirza (1994), Schoener (1974) and Southwood (1977) mentioned that characteristics of the water habitats influence feeding, reproduction and survival of the fish by affecting their physiology, behavior and genetics. Thus, this study was conducted to characterize the water quality of aquatic resources/ecosystems harboring edible fish, shell and related species in the province Benguet.

Materials and methods:

The major river ecosystems sampled in the study were determined through aerial survey of Benguet Map. Emphasis was laid on aquatic ecosystems which are not polluted by agricultural run-off and domestic wastes. Sampling stations in selected rivers were established. Transect lines measuring 20 meters were set in each of the sampling stations. In each sampling station, the physical and chemical parameters were measured. The measured physical parameters include temperature, water depth, substrate composition and velocity. The air, surface waters and under water temperatures were determined and averaged. Air temperature was obtained by suspending the thermometer 20 cm above the water surface while surface water was determined by dipping the thermometer five cm below the water surface. On the other hand, the water depth was measured by submerging a heavy weight tied to a calibrated rope until it reaches the substratum. The substratum of the sampling stations was determined through the 'feel method' classifying it as rocky, clayey, and sandy or silty using a standard guide. Lastly, the velocity of water was determined by floating a ping pong ball or empty plastic containers along the 20 m transect line. The rate of flow was computed by determining the time it takes the ping pong ball to reach the end of transect divided by transect length.

Chemical parameters measured include pH, dissolved oxygen (DO) and nutrient content such as nitrate, ammonia and phosphorus. The pH of the water was obtained by dipping a pH meter on water surface. On the other hand, DO, nitrate, ammonia and phosphorus were analyzed in-situ using the HACH Kit Test. All parameters were measured with three trials. The nutrient content of the water is also an important indicator of the impact of synthetic-fertilizer-and-pesticide-heavily-inputted vegetable farming on the province's river systems. Water sampling was conducted from May 2008 to June 2009.

Results and discussion:

Major Rivers of Benguet Sampled

Table 1 presents the major river systems of Benguet sampled in the study and Figures 1 to 12 (see Annexes) show the sampling stations. At least one river/tributary per municipality was determined to derive a random representative sample. All of the sampled water bodies encompass lotic ecosystems except Ambuklao Dam. The dam has standing waters categorizing it as a lentic ecosystem, albeit, an artificial one.

It can be gleaned from the table that there are five major river systems in Benguet which is consistent with records of Provincial Veterinary Office (PVO 2002). These include Agno, Amburayan, Amposongan, Galiano and Naguilian Rivers. The other two, Abra and Bayating Rivers, have either headwater or tributary from Benguet. Five sampling sites were established along Upper Agno River System; two each in Amburayan and Bakun River System; and, one each in Galiano and Naguilian Rivers.

These rivers were selected based on the presence of freshwater fish, shell and related species. Also, the cleanliness of water was considered since severely polluted rivers do not harbor fish and shell. If they do, most of the inhabitants are contaminated and unfit for human consumption. Initial water assessment based on key informants was used to determine rivers that have not been severely subjected to mining and other polluting activities.

Table no. 1 Major rivers/tributaries of Benguet sampled

Local name of the Communal water	Major River System	Location	Remarks
Ambuklao Dam	Upper Agno River	Ambuklao, Bokod	Lentic
Karao River	Upper Agno River	Karao, Bokod	Tributary
Upper Agno River	Upper Agno River	Kabayan Barrio, Kabayan	Mainstream
Eddet River	Upper Agno River	Eddet, Kabayan	Tributary
Agno River	Upper Agno River	Tinongdan, Itogon	Mainstream
Amburayan River	Amburayan River	Taba-ao and Cuba, Kapangan	Mainstream
Asin-Lewen River	Amburayan River	Poblacion, Kibungan	Tributary
Poblacion River	Amposongan River	Poblacion, Bakun	Tributary
Sinacbat Creek	Amposongan River	Sinacbat River	Tributary
Dopi River	Abra River	Cabiten, Mankayan	Tributary
Galiano River	Galiano River	Nangalisan, Tuba	Mainstream
Sab-dang River	Bayating River	Sab-dang, Poblacion, Sablan	Headwaters
Payay-Asin River	Naguilian River	Tuel, Tublay	Tributary

Physical Parameters

Temperature

The physical parameters, including the temperature range and mean, are presented in Table 2 (see Annexes). Payay-Asin, Ambuklao Dam, Amburayan and Sab-dang Rivers have the highest mean temperatures of 28, 25.2, 24.2 and 24.2 ºC, respectively. On the other hand, Poblacion and Sinacbat Rivers, both tributaries of Amposongan River, registered the least mean temperatures of 19.1 and 19.2 ºC. Statistical analysis showed that the temperatures of the various sampled rivers differed significantly. The variation in temperature of the sampled bodies of water is attributed to several factors including the elevation, the time of the day and the season when the sampling was done. Also, the sampling accounts for air temperature, which is generally higher than the actual water temperature. The relatively high temperature of Payay-Asin River is attributed to the presence of hot spring in the river bed while in Sab-dang River, its low elevation explains its warm waters. On the other hand, the warm temperature of Ambuklao Dam could be owed to its lentic state. Basically, lentic ecosystems have higher temperature than flowing rivers.

The DENR Administrative Order No. 34 Series of 1990 (DAO 1990) sets water quality standards for surface waters - both freshwater and marine - depending on the water class. Unfortunately, there is no standard value for temperature. Nevertheless, increase in water temperature for any water class should not exceed 3 °C. Higher temperature rise, particularly at 5 °C increase, is detrimental to the fishes. Tague (undated) stated that 25 °C or a range of 22-27 °C is the optimum temperature for tropical fish thus it is recommended for aquariums. These values are generally higher than the water temperatures in the rivers of Benguet.

Temperature is one of the key limiting factors on the productivity and biodiversity of aquatic ecosystems in Benguet. Since fish are cold-blooded organisms, their body temperature changes with the environment and affecting their metabolic rate. Temperature requirements, if not met, can adversely affect feeding, food conversion and growth (SEAFDEC 2003). Due to the semi-temperate climate of the province, the water bodies are relatively colder than their lowland counterparts. As a result, the productivity and biodiversity of the said ecosystems are generally low since not many species can adapt to the colder temperature.

Depth

Water depth of sampled rivers depicts shallow waters generally not exceeding 2 m, except in Ambuklao Dam which has a depth of 60 m. This implies that light penetration in these waters is at maximum (100%) since light can basically penetrate at a maximum depth of 200 m. Thus, photosynthetic activities are possible down to the substratum in all of the sampled water bodies. Deposition of silt and sediments in Ambuklao Dam greatly reduced its depth and caused its inability to generate power. Below 100 meter depth, the dam facilities cannot function. As of the present, it is primarily used for aquaculture of tilapia and carp while undergoing rehabilitation.

Pires et al. (1999), Bain et al. (1988) and Lobb and Orth (1991) regarded water depth with other water characteristics as important factors influencing fish community structure. The deeper and larger the water, the greater the living space it could provide for the fish. This, in turn, redounds to the carrying capacity of the river or stream. It likewise explains why pools have greater productivity than riffles. The shallow depth of sampled rivers explains why even light penetration is at 100%, their productivity still is minimal.

Velocity

Velocity is one of the limiting factors as well as the determinant of a lotic ecosystem. The fast flow of water disrupts the establishment of the population of (potamo) phytoplankton. Fishes and other aquatic life forms in rivers also have to adapt to this, which explains why lotic ecosystems are generally less productive than lentic ones. However, the velocity or the flow is what makes a river a river. In addition, the flow of the water facilitates the solubility of oxygen in water.

During sampling, the velocity of some rivers was not measured due to perilous situations or inadequate flow. Poblacion and Asin-Lewen Rivers have the highest velocity of 2.8 and 2.7 m/s while Galiano and Eddet Rivers have the least at 0.2 and 0.7 m/s, respectively. The fast flow of Poblacion and Asin-Lewen Rivers is characterized as turbulent. The variations in velocity are attributed to several factors. Velocity fluctuates with changing water level as caused by rainfall, slope, presence of barriers and others. Of the study sites, Galiano River has the slowest velocity and this could be attributed to the relatively flat portion of the river where the sampling was conducted. On the other hand, Eddet River was sampled during summer when water level was low. In contrast, Asin-Lewen River was sampled during rainy season while Poblacion River was sampled at its running slope portion.

Substratum

Substratum or the riverbed plays an important role in fish communities primarily as spawning ground for many fishes. Also, holes or crevices along riverbeds provide refuges for many aquatic species. Substratum of streams usually consists of sand, gravel, cobbles and rocks (Thompson and Larsen 2004). Consistently, the majority of Benguet rivers have rocky sandy substratum except Ambuklao Reservoir and Payay-Asin River. Sedimentation and siltation from erosion resulted in the silty sandy riverbed of Ambuklao and clayey rocky of Payay-Asin River. The clayey substratum of Payay-Asin River harbors an ample population of shells. Usually, these shells are found in rice paddies but may have been dislocated due to conversion of these paddies into vegetable gardens.

Substratum is constantly being changed by the flow of water. Slow flowing waters would deposit sediments, organic matter and other particles while fast flowing waters would strip any loose materials in the riverbed. These have been disrupted and aggravated by human activities particularly the occurrence of erosion. Sediments would be carried downstream covering and destroying the in-stream habitats of fishes. This is particularly true in the case of river eels. This fish thrives in rock crevices but the deposition of sediments and silts into these crevices render the fish homeless and/or trapping it. Studies of Jungwirth et al. (2002) on streams of Austria established that the reduced heterogeneity of riverbeds, due to sedimentation, resulted to decreasing number of fish species, fish density and biomass.

Chemical Parameters

pH

Results of sampling on the different rivers established that all are within the water quality criterion set under DAO (1990), except Payay-Asin that has a pH of 8.9 (Fig. 13). The basic water of Payay-Asin River is attributed to the presence of hot springs which release sulphuric compounds. The calcium carbonate concentration of the water could also be high as indicated by the occurrence of shells in the substratum. These two compounds are both alkaline. Together with Payay-Asin River, half of the sampled rivers have basic waters. This could be attributed to occurrence of calcium carbonates in the water. This compound is naturally occurring on rocks being weathered and absorbed by the flow of water. Shells as wells as crustaceans like crabs indicates the presence of such compounds as it is the main component of their exoskeleton.

Similar with DAO (1990), the ideal pH for fish production is at 6.5 to 8.5 but fish can survive at pH ranging from 5 to 9. Exposed at a pH below 4 or higher than 11, the fish dies; at pH 4 in-between 5, no reproduction occurs; and at pH 5 in-between 6.5, the growth of fish is slow. Fortunately, the pH of the sampled rivers is within the optimum pH for fish production.

Dissolved Oxygen

The dissolved oxygen (DO) concentration of the rivers is presented in Figure 14. All the rivers have DO levels ranging from 7 to 8.5, higher than the 5 mg/L minimum standard value for DO. The optimum DO for fish production is 7 to 8 mg/L. The DO of the sampled rivers is within this range. These high DO concentrations of the rivers are attributed to turbulent flow of water as wells as the photosynthetic activities of aquatic plants such as algae.

DO is critical to fish survival. The saturation concentration is a function of water temperature and atmospheric pressure which is determined by elevation. DO is directly related to atmospheric pressure and inversely related to water temperature. The maximum amount of DO that water can hold is 14.7 mg/L at sea level and 0 ^{o}C. Sources of DO include aeration brought by flow motion of the water and photosynthetic activity of aquatic plants. On the other hand, DO is depleted through respiration (from fish and aquatic plant), decay of organic matter, direct chemical oxidation and outflow of water (Brown - in Thompson and Larsen 2004).

Figure no. 13 The pH level of the river study sites compared to the water quality criterion (DAO 34 series [1990]); LR - lower range; HR - higher range)

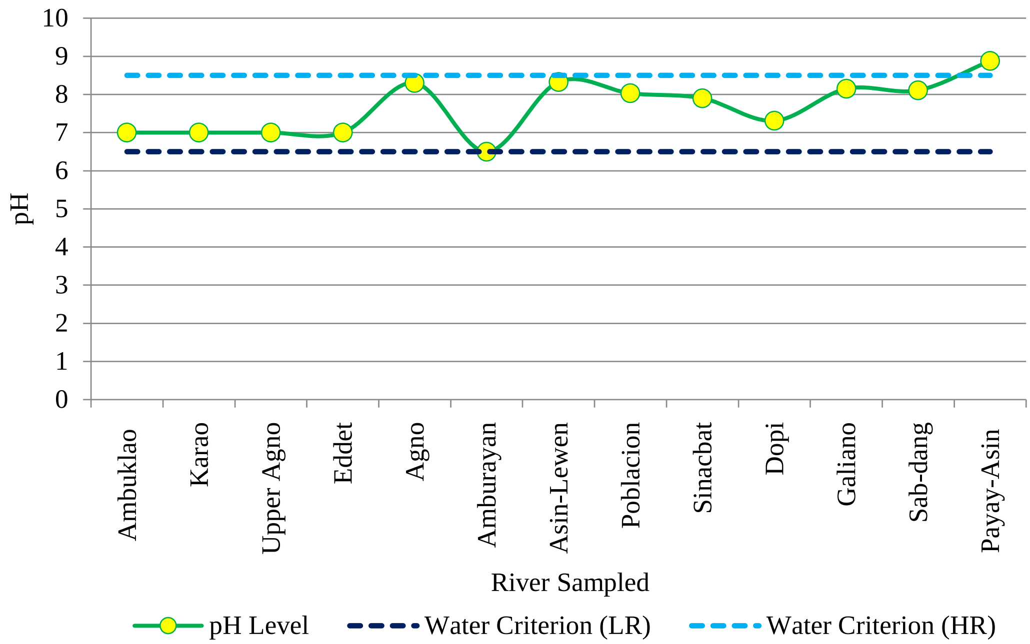
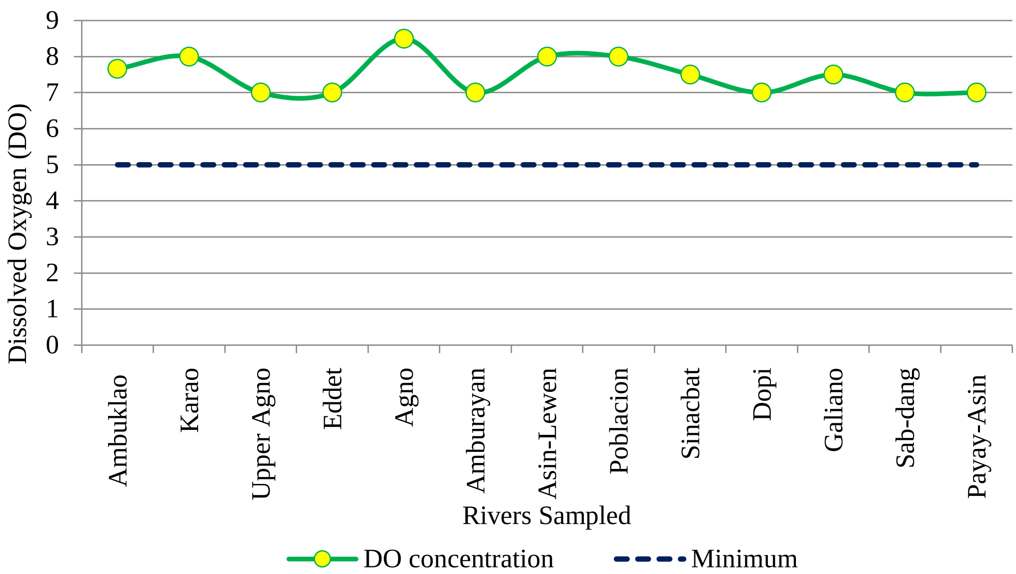


Figure no. 14 The DO concentration of the sampled rivers compared with the standard (DAO 34 series [1990])



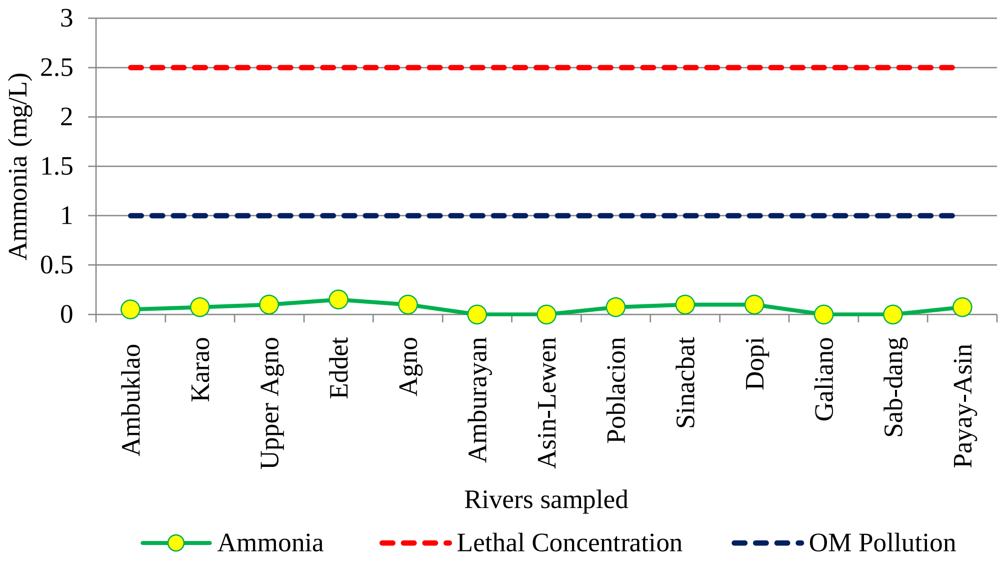
DO is considered the most important chemical parameter due to its role in supplying oxygen for the respiration of all animals present in an aquatic ecosystem. It can also be the means of measuring productivity and pollution strength of the water. Tchobanoglous (1991) stated that the presence of DO prevents the formation of noxious odor. Hence it used as an indicator of pollution in the water (Umaly and Cuvin 1988). Generally the higher the DO concentration, the cleaner the water. Thus, the high DO concentrations in the sampled rivers strongly suggest that their waters are still clean and viable to support aquatic life.

Ammonia

Ammonia (NH_3), a nitrogen compound, is a natural and normal occurrence in freshwater due to fish metabolism and microbial decay of organic matter (HACH Company 1993). The process wherein the organic matter is broken down into ammonia is termed ammonification. Ammonia together with other nutrients induces eutrophication.

The ammonia content of the sampled rivers ranges from 0 to 0.15 mg/L (Fig. 15). Eddet River registered the highest concentration at 0.15 while Amburayan, Asin-Lewen, Galiano and Sab-dang Rivers have no ammonia detected. Interestingly, Ambuklao Dam has low concentration of 0.05 mg/L despite the presence of tilapia culture in its waters. These values are generally within the ideal ammonia level for fish production (0.1 mg/L). Therefore, this range is much below the lethal ammonia concentration at 2.5 mg/L and the 1 mg/L level that indicates organic matter pollution.

Figure no. 15 Ammonia concentration of the sampled rivers compared against the lethal concentration for fish and organic matter pollution level



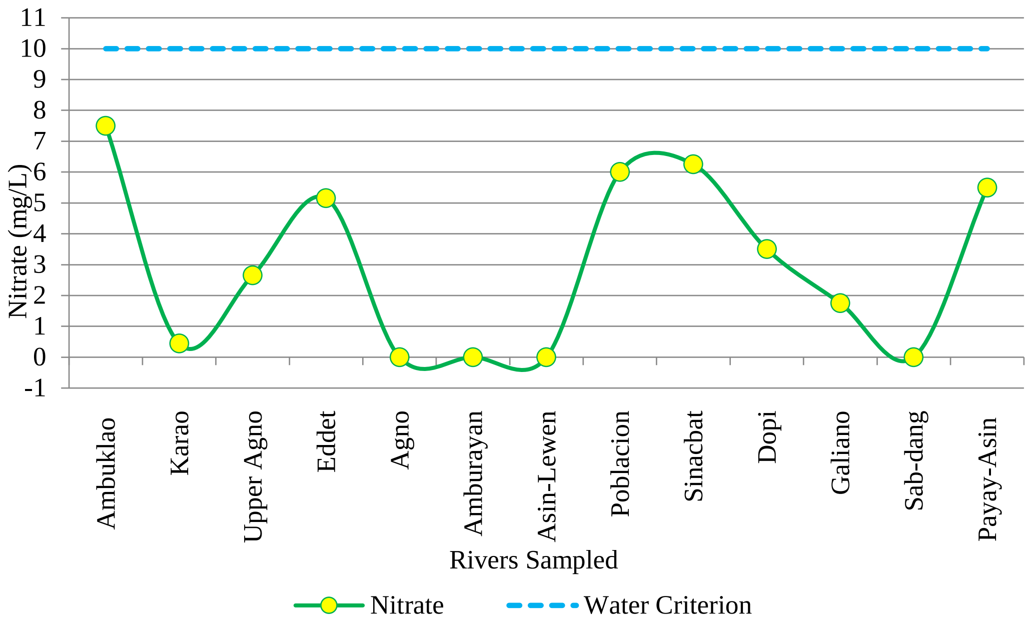
The low concentration of the ammonia in Ambuklao Dam could be attributed to the quick oxidation of this compound into nitrate by bacteria and algae (Chaim and Patiño - in Adanglao et al. 2006). This results in the high nitrate concentration of the dam as further explained. On the other hand, Eddet River has ammonia slightly higher than the 0.1 mg/L criterion which could be attributed to its slow flow and does not readily flush down organic particles. Amburayan, Asin-Lewen, Galiano and Sab-dang Rivers, in contrast, were sampled during rainy season thus there is greater water that dilutes and flushes debris. Furthermore, ammonia increases with temperature and pH. Thus, the low temperature of the sampled rivers also engenders the low concentration in ammonia.

Nitrate

Nitrate (NO_3), also a nitrogen compound, is a product of the process called nitrification where ammonia (NH_3) is converted to nitrite (NO_2^-) by *Nitrosomonas* bacteria and nitrite is oxidized into nitrate by *Nitrobacter* species. Nitrate is less toxic than ammonia or nitrite but still high levels can potentially cause death of fish. The permissible level for nitrite is 0.06 mg/L while most fish can tolerate 30-40 mg/L nitrate concentration. Other studies showed that aquatic species can tolerate a concentration greater than 100 mg/L claiming that nitrates are generally not a great concern to aquacultures. However, nitrate together with other nutrients induce eutrophication.

Figure 16 shows the nitrate levels of the sampled rivers against the water quality criterion (DAO 1990). It can be gleaned from the figure that all of these rivers have lower nitrate than the 10 mg/L standard. Ambuklao Dam has the highest concentration at 7.5 mg/L followed by Sinacbat, Poblacion and Eddet River with concentrations of 6.25, 6 and 5.15 mg/L, respectively. The high nitrate concentration of these waters is attributed to agricultural run-off from the vegetable gardens that predominate on the upper slopes. Vegetable gardens in the province are characterized by heavy use of synthetic fertilizers and pesticides thus residues of these compounds usually reach water bodies. This is particularly noted in Buguias which is one of the headwaters of Agno River. Furthermore in Ambuklao Dam, nitrification of ammonia contributes to the accumulation of nitrate in the water. This may explain the low ammonia concentration in the dam, in contrast to its high nitrate level.

Figure no. 16 Nitrate concentrations of the sampled rivers compared with the water criterion



As observed, the water in the dam is greenish indicative of vigorous algal growth. This algal growth helps reduce nitrate accumulation. Also, algae provide food for the relatively high population of fishes in the dam, particularly tilapia, carp and freshwater shrimps. Hence, it could be concluded that the high nitrate level enhances the productivity of this ecosystem. Moreover, the harvest of fish in the dam also means harvest abounding in nitrate.

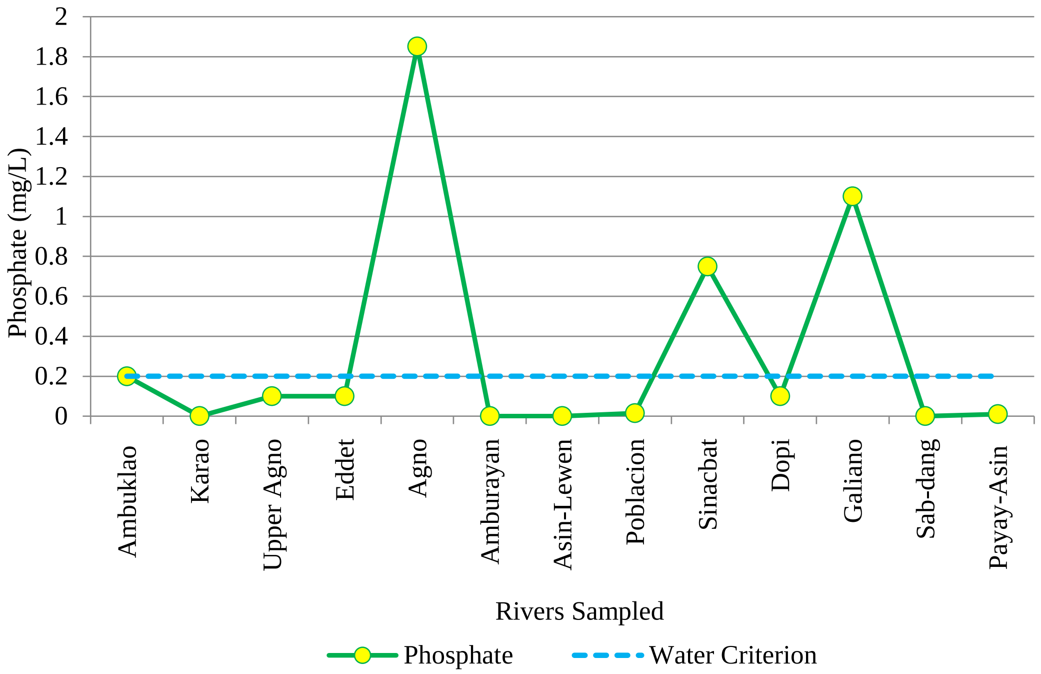
Phosphate

Phosphate (PO_4) is a valuable nutrient both in agricultural areas and aquatic ecosystems. Phosphates are the usual biologically limiting elements in freshwaters. Phosphates are intricately linked to nitrate in terms of primary production (algal growth) to such an extent that their elemental composition falls under a set N:P ratio called the Redfield ratio. The Redfield ratio commonly falls between 15 or 16 N is to 1 P (16:1). At higher ratio, say 20:1, phosphate becomes limiting (Correll et al. 1999). On the other hand, high levels of phosphates do not harm fish directly but the algae bloom that results from high concentrations of phosphate and nitrate can ultimately cause problems on aquatic ecosystems and the inhabitants. For instance, green water can deplete the oxygen, which in turn suffocates the fishes.

Aquatic ecosystems are naturally low in phosphate. The ideal phosphate level for aquaculture is 0.05 mg/L. At 1 mg/L, the condition enables algal growth to start. With higher concentration, say 2 to 3 mg/L, algal overgrowth is likely to occur. The water criterion for phosphate under DAO 34 series (1990) is 0.2 mg/L. However, the maximum permissible level for fish production is pegged at 0.3 to 0.4 mg/L.

Figure 17 presents the phosphate level of the sampled rivers. Except three, all the rivers are within the water criterion. Agno, Galiano and Sinacbat Rivers have high concentrations of phosphate at 1.85, 1.1 and 0.75 mg/L, respectively.

Figure no. 17 Phosphate concentrations of the sampled rivers compared with the water criterion



The high concentration of these rivers is attributed to several factors. For Agno and Sinacbat Rivers, the foremost cause would be leaching of phosphates from agricultural areas located on the upper slopes. As stated earlier, Agno River has tributaries stemming from Buguis, Kabayan and Bokod that are under intensive fertilizer applications, while rice paddies using synthetic fertilizers predominate on the upper slope of Sinacbat River. Another possible source of phosphate would be from the natural rock deposits that have been weathered by the flowing water. It was noted that the fast flow of Agno River constantly stirs the sediments, releasing the bound phosphate.

Also, this fast flow discourages the establishment of algae and plankton populations which could have absorbed and reduced the phosphate level in the water. On the other hand, the high phosphate concentration of Galiano River is attributed to the urban wastewater containing detergents and sewages stemming from its headwater and tributaries in Baguio City. Also, hot spring resorts aligned in the upper river bank would mostly likely dump detergent-laden wastewater into the river.

Ambuklao Reservoir, interestingly, has low phosphate concentration. Initially, the dam was expected to harbour high levels of phosphate since it serves as a major catch basin for agricultural run-off as well as the presence of fish culture in its waters. Fish faeces and fish feeds contain significant amounts of phosphate. But on the contrary, its phosphate content was only 0.2 mg/L still lying within the water quality criterion.

This low concentration, however, does not mean that the water is really low in phosphate. However, this concentration rather refers only to the soluble inorganic phosphate which the test kit can only measure. The other form of phosphate content in water - the ‘soluble reactive phosphates or the available form’- has been absorbed by the vigorous growth of algae.

Implication to Aquatic Resources

Understanding the relationship between fishes and their habitats is important for conservation and resource management. Characteristics of the water habitat influence feeding, reproduction and survival of fish species by affecting their physiology, behavior and genetics (Schoener 1974; Southwood 1977). Several studies have reported a correspondence between fish distribution and environmental variables. Also, several researches confirmed the longitudinal changes in fish assemblages along an upriver-downriver environmental gradient. Beecher et al. (1998) and Oberdorff and Porcher (1992) observed that species richness decreased significantly with increasing altitude and vice versa. This is attributed to several factors. Moyle et al. (2003) showed that different fish species could be separated on environmental gradients, determined largely by elevation, temperature, flow of water and the emergent vegetation. Pires et al. (1999), on the other hand, considered water temperature, water depth, width of river and the type of substratum as the fundamental factors determining the fish community. Additionally, studies by May and Brown (2000) determined that distribution of different fish species was positively or negatively correlated with velocities and water depth, while the other physico-chemical parameters had no effect.

These studies convey the fact that factors affecting fish communities vary. That is because those studies are conducted in different rivers, thus, the prevailing environmental conditions are not the same. In the case of Benguet rivers, the temperature and the river size (width and depth) have the greatest impact on aquatic fauna. Consequently, they are the most limiting factor. The other factors like pH and DO are ideal for fish production. The low temperature of these rivers, owing to its high elevation, limits the productivity and biodiversity of aquatic resources since not many fish or shell species can tolerate cold temperature. Also, being the headwaters or tributaries, these aquatic ecosystems are generally shallow and narrow. This limits the living space available for fish, thus, limiting also the carrying space of the rivers. This, in turn, results to the low biodiversity and productivity of the studied rivers.

Fortunately for Ambuklao, it has been dammed for power generation. Consequently, it also provides a wide stretch of water for fish habitation. The standing water together with its relatively high nutrient content favours plankton and algal growth which provides food to the aquatic faunal species. This is indicated by the greenish colour of the water especially during summer. These factors, together, make the dam a very productive aquatic ecosystem. Records of the Bokod Municipal Agriculture Officer showed that the fresh weight biomass of fish and shell being harvested reach 192.57 metric tons/annum.

Conclusions:

The water quality of major rivers in Benguet Province was sampled. In terms of physical parameters, the rivers generally have cold temperature, rocky sandy substratum, shallow depth, full light penetration and fast flow (except Ambuklao Dam). The cold temperature, shallow depths and fast flow are the major limiting factors in these rivers. The low temperature of these rivers, owing to its high elevation, limits the productivity and biodiversity of aquatic resources since not many fish or shell species can tolerate cold temperature. Also, being the headwaters or tributaries, these aquatic ecosystems are generally shallow and narrow. This limits the living space available for fish, which further limits the carrying capacity of the rivers. This, in turn, results in the low macro-faunal diversity and productivity of the studied rivers. Only Ambuklao Dam has relatively high productivity which could be attributed to its lentic state, wide open habitable space and relatively higher nutrient content. On the other hand, results of the chemical parameters showed that most of these rivers are within the water quality criteria set in DAO 34 series (1990). pH range from 6.5 to 8.9 while DO ranges in-between 7 to 8.5 mg/L, both being ideal for fish production. Ammonia and nitrate content of all rivers is within the water criterion while some rivers have high phosphate content. The high phosphate content in some rivers is mostly attributed to run-off or leaching of fertilizer residues from vegetable farms and from detergents-laden wastewater. Nonetheless, phosphate does not directly harm fish, even at high levels. Thus, it could be concluded from these results that despite pollution from vegetable farming, residential and mining activities, the major river systems in Benguet are still clean. Furthermore, the chemical characteristics of these rivers also lie within the tolerable range for aquaculture.

Rezumat:

EVALUAREA CALITĂȚII APEI DIN SISTEMUL MAJOR DE RÂURI DIN PROVINCIA BENGUET, FILIPINE

Calitatea apei râurilor din provincia Benguet a fost determinată utilizându-se diferiți parametri fizici și chimici, ca parte a efortului de a caracteriza habitatele de apă dulce pentru peștii și scoicile indigene din provincie. Acest lucru a fost făcut, de asemenea, pentru a determina starea râurilor ca urmare a presiunilor din partea agriculturii, a activităților rezidențiale și miniere. Un total de 12 râuri au fost eșantionate în mod intenționat pentru a reprezenta toate municipalitățile din provincie. În ceea ce privește parametrii fizici, râurile au în general o temperatură scăzută, un substrat pietros nisipos, o adâncime mică, o penetrare totală a luminii și curenți rapizi (cu excepția barajului Ambuklao). Temperaturile joase ale râurilor, cuplate cu adâncimile mici și curenții rapizi, au contribuit la o biodiversitate și productivitate scăzută a acestor cursuri de apă. Pe de altă parte, pH-ul, conținutul de

oxigen dizolvat, azotat, amoniac și fosfat din aceste râuri, se situează în cea mai mare parte în criteriile de calitate a apei stabilite de Departamentul pentru Mediu și Resurse Naturale, Ordinul Administrativ nr. 34 din 1990. Astfel, se poate concluziona din aceste date că, în ciuda presiunilor rezultate din activitățile fermelor de legume, rezidențiale și miniere, sistemul major de râuri din Benguet este încă curat. S-a observat că deversările de substanțe chimice de sinteză provenite de la fermele de legume, afectează în mare parte aceste râuri. Totuși, caracteristicile chimice ale acestor râuri se încadrează în domeniul optim pentru acvacultură. Aceste calități ale apei trebuie considerate ca repere ce trebuie respectate atunci când se are în vedere cultura de specii indigene de pești și moluște.

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Annexes:

Figure no. 1 Ambuklao Reservoir in Bokod

Figure no. 2 Karao River in Karao, Bokod

Figure no. 3 Upper Agno River in Kabayan

Figure no. 4 Eddet River in Eddet, Kabayan

Figure no. 5 Agno River in Tinongdan, Itogon

Figure no. 6 Amburayan River in Kapangan

Figure no. 7 Asin-Lewen River in Kibungan

Figure no. 8 Poblacion River in Bakun

Figure no. 9 Payay-Asin River in Tuel, Tublay

Figure no. 10 Dopi River in Cabiten, Mankayan

Figure no. 11 Galiano River in Nangalisan, Tuba

Figure no. 12 Sab-dang River in Poblacion, Sablan

Table no. 2 The physical attributes of the sampled rivers

River Sampled	Temperature (ºC)		Depth (cm)		Velocity (m/s)	Substratum	Light Penetration
	Range	Ave	Range	Ave			
Ambuklao Dam	23.4-25.2	25.2	6000	6000	-	Silty sandy	100%
Karao River	19.7-22.7	19.8	24-48	107.0	-	Rocky sandy	100%
Upper Agno River	19.7-22.2	19.8	86-250	172.0	1.6	Rocky sandy	100%
Eddet River	19.6-22.2	19.6	30-45	38.0	1.3	Rocky sandy	100%
Agno River	23	23.0	108-164	143.0	0.7	Rocky sandy	100%
Amburayan River	24-27.6	24.2	53.4-74.2	63.8	-	Rocky sandy	100%
Asin-Lewen River	20.5-21	20.3	39-75	53.0	2.7	Rocky sandy	100%
Poblacion River	18.5-19.5	19.1	53-58	55.5	2.8	Rocky sandy	100%
Sinacbat River	19.2	19.2	178	178.0	-	Rocky sandy	100%
Dopi River	23	23.0	21.5-29	25.3	1.5	Rocky sandy	100%
Galiano River	22-25	23.5	74.7-97	85.9	0.2	Rocky sandy	100%
Sab-dang River	24.2-25.5	24.2	35-52	42.0	-	Rocky sandy	100%
Payay-Asin River	28	28.0	14-48	31.0	0.9	Clayey rocky	100%