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pH ADJUSTMENT OF ACID FRESH WATER AT MATRE AQUACULTURE STATION:
EXPERIENCES WITH PREVIOUS AND EXISTING METHODS.

by

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ABSTRACT

The water from Matre River is characterized as very soft, with a total hardness of 1.5 - 2.5 mg CaO/l and a very low buffer capacity. Acid precipitation results in low pH, values below 5.0 are recorded every year. As a consequence of the water quality, several systems for pH adjustment has been tried, most of them having evident limitations. In this paper several of them has been described and evaluated. A special attention has been put on the two systems which at the moment are beeing used at the station and which we think are holding promise. These are the neutralizing systems based on the addition of sodium hydroxide and well pumped salt water.

INTRODUCTION

Acidificaton of fresh water is a major environmental problem in the rearing of salmonids in southern Norway. The problems with acid rain are worst in the snow-melting period in spring (Overrein, Seip and Tollan, 1981), and usually coincide with the eggs, larval and smolt stages of the salmonids in question. In the affected regions this may cause heavy mortalities. In an investigation throughout the whole life cycle of the non-anadromous brook trout (Salvelinus fontinalis)(Menendez, 1976) the eggs and larval stages were found to be the most vulnerable. And in a corresponding investigation on the anadromous Atlantic salmon (Salmo salar) Rosseland and Skogheim (1982) the smolt stage has been shown to have even higher sensitivity.

pH adjustment by liming has a long tradition in norwegian hatching and rearing of salmonids (e.g Sunde, 1926), but to achive a efficient and reliable system has been difficult.

Matre Aquaculture Station use water from the Matre River. The water is characterized as very soft, with a total hardness of 1.5 - 2.5 mg CaO/l and with a very low buffer capacity. Acid precipitation results in low pH, values below 5.0

are recorded every year. As a consequence of the water quality, several systems for pH adjustment have been tried, most of them having evident limitations. In this paper several of them are described and evaluated. A special attention has been put on the two systems which at the moment are being used at the station and which we think are holding promise. These are the neutralizing systems based on the addition of sodium hydroxide and saline ground water.

NEUTRALIZATION METHODS

SEAWATER ADDITION (AUTUMN 1971 - AUTUMN 1974)

In the first period after the start at Matre Aquaculture Station seawater was used to raise the pH of the acid freshwater. Seawater raises pH efficiently (Fig.1) and give a very stabile pH. This method was used with success until the autumn of 1972. This autumn the fry suffered 30-40% mortalities due to the bacterial disease Vibriosis. In the period autumn 1973 to autumn 1974 this disease repeatedly caused mortalities and the seawater addition was consequently ended.

ADDITION OF CALCIUM HYDROXIDE (AUGUST 1974-WINTER 1976)

During the period from august 1974 until the winter of 1976 both calcium hydroxide ($90\% \text{CaOH}_2$) and limestone powder (CaCO_3) was used as neutralization agents. Several systems was tested, both in the catchwater drain up in the river and in the river water reservoir at the station. Clogging and consequently great pH fluctuations was, however, a common problem. Variations of up to 2 pH units per day was measured at several instances.

It was nessessary to add 2.6 kg calcium hydroxide per m^3 water per day to raise the pH from 5.0 to 6.5. For limestone powder, which is a much weaker base, eight times this amount was needed. Both addition of calcium hydroxide and limestone

powder increased the hardness of the water. The increase was, however very low, amounting to approximately 1 mg CaO/liter. Another great problem concerning this methods was gill irritations which occured frequently during this period. This was probably caused by undissolved particles of the neutralizing agents. These particles also settled in the fish tanks.

SHELLSAND WELL (WINTER 1976-WINTER 1981)

In connection with a rebuilding of the station's water supply during the winter 1976 a shellsand well (Fig. 2) was placed in the river water reservoir. At temperatures above 6 - 7 °C and by a daily addition of from 30 to 50 kg of shellsand this system was able to maintain a pH of 6.0 +/- 0.5. However, at temperatures below 3 - 4 °C the effect was low. Another great problem concerning this system was that it was nessessary to keep the shellsand in suspension to maintain a steady pH regulating effect. Moreover, the refilling routine caused great daily variations and the low solubility caused settling of shellsand in the fish tanks.

ADDITION OF SODIUM HYDROXIDE (MAY 1981-PRESENT)

In may 1981 the shellsand well were replaced by a automatic system based upon liquid sodium hydroxide. This system (Fig. 3) includes two 800 liter plastic tanks, two pumps, a water filtering unit, an ejector, and a float valve. All plumbing is made of PVC. The system is placed upon the concrete catchwater drain which is situated some 900 meters up the Matre river.

River water is pumped from the catchwater drain through the filtering unit and through the ejector. The capasity of the filtering unit can be read out on pressure gauges, one in front and one behind the filter. The filter are replaced when the pressure gauges show differential readouts, normally four

times a year. This is easily done by closing the stop cock in front of the filter and then replacing the filter cartridge. The suction which is generated in the ejector draws 50% NaOH from the 800 liter holding tank and mixes it with the water. The amount of NaOH mixed into the water in the ejector can be read out on the flow-meter and are regulated with the dosings valve, normally to give a 2% NaOH solution. From the ejector the diluted NaOH enters the second 800 liter tank. When this tank is full a float switch deactivates the pump and closes the solenoid valves. When there are less than 200 liters left on the tank the solenoid valves opens and the pump are reactivated. By the means of a dosings pump the diluted NaOH is pumped continuously through the counterpressure valve and into the inlet tank. In cases of power failure this counterpressure valve prevents the sodium hydroxide from pouring into the inlet tank. In the reservoir at the station the pH is automatically registered with an electrode which is connected to an alarmsystem. This system is set to alarm if the pH is lower than 6 or higher than 8.

The sodium hydroxide raises pH very efficiently. A daily addition of 30 litre of the 50% solution is enough to raise the pH of all the river water used at the station (4 m /min) from between 4.5 and 5.5 to between 6.0 and 6.5 (Fig. 4). The dosing of the sodium hydroxide is regulated after the pH in the river water. Normally it is sufficient to do this once or twice during the autumn and spring. Occasionally, however, minor regulations can be needed during summer and winter.

The addition of sodium hydroxide not only regulate the pH, it also effects the aluminium components in the water. In Fig. 5A is shown the pH in the river water during a snow melting period in the beginning of april 1984. The highly increasing acidity is accompanied by an increase in total acid reactive aluminium (Fig. 5B). The peaks in labile aluminium are, however, damped by the sodium hydroxide addition (Fig.5C).

ADDITION OF SALINE GROUNDWATER (MARCH 1983-PRESENT)

The ground water well consist of a 17 meter long 4 inches wide stainless steel pipe which has been drilled into the ground near shore. From this well, the salt groundwater is pumped directly into the pipeline which lead to the fish tanks.

In table 1. is given some data on the water quality of the pumped ground water compared to water obtained from the ordinary sea water used at the station. Typical of the saline ground water is a very stable temperature and salinity and a low bacterial number and oxygen saturation. At present, 120 m³/hour of acid power plant effluent is mixed with the saline ground water to give a salinity of 8 ppt. The resulting pH is very stable at 6.9 or 7.0. Moreover, no mortalities neither due to aluminium nor Vibriosis has been registred in fry reared in this water quality.

DISCUSSION

During more than three years the sodium hydroxide has been used with success at Matre Aquaculture Station and has improved survival of eggs and fry of both rainbow trout (Salmo gairdneri) and Atlantic salmon (Salmo salar). This is not concurrent with the results of Bua and Snekvik (1972) who found that addition of NaOH reduced the prehatching mortality of trout (Salmo trutta) and char (Salvelinus alpinus) but to a less extent of salmon.

The toxicity of acidified waters seem to be both a pure pH effect as it disturbs the osmolarity or the saltcontent in the fish blood (Packer and Dunson 1976, Leivestad et al., 1976) and a secondary effect of low pH, elevated levels of aluminium in the water (Schofield 1977, Munitz and Leivestad 1980, Rosseland and Skogheim 1982).

In earlier experiments at Matre Aquaculture Station it has

been shown that both addition of citrate and phosphate had positive effects on the water quality (Ingebrigtsen, 1982), however, seawater addition gave clearly the best results. The positive effect of adding seawater to acidic is not yet fully understood. The main advantage of sea water is probably its very efficient bicarbonate buffer system which keep the pH stable over a wide range of salinities, and keeping pH above 6.0 where there probably is very little effect of aluminium on fish (Muniz and Leivestad, 1980). As is established for waterborne copper and zinc the toxicity of these metals is considerably reduced when calcium is added to the water (NAS, 1972). Thus calcium added with seawater may also have a positive effect when otherwise toxic aluminium concentrations in the water are to be expected. Moreover, there may be some slight growth benefit in the isosmotic range (Brett 1979). The greatest problem concerning the use of seawater is of course the risk of bringing in the bacteria Vibrio anguillarum. One way of reducing this risk is to sterilize the water by the means of uv-light, ozone treatment or heat. Another method which easily can be used in farms near the sea is to use saline ground water from a drilled well.

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Table 1. A comparison between ordinary sea water and saline ground water at Matre Aquaculture Station.

	TEMP °C	BACTERIA number/ml	OXYGEN % saturation	SALINITY ppt
SEA WATER	4-15	80-400	95-100	28-33
SALINE GROUND WATER	8-10	0-100	8-20	28-29

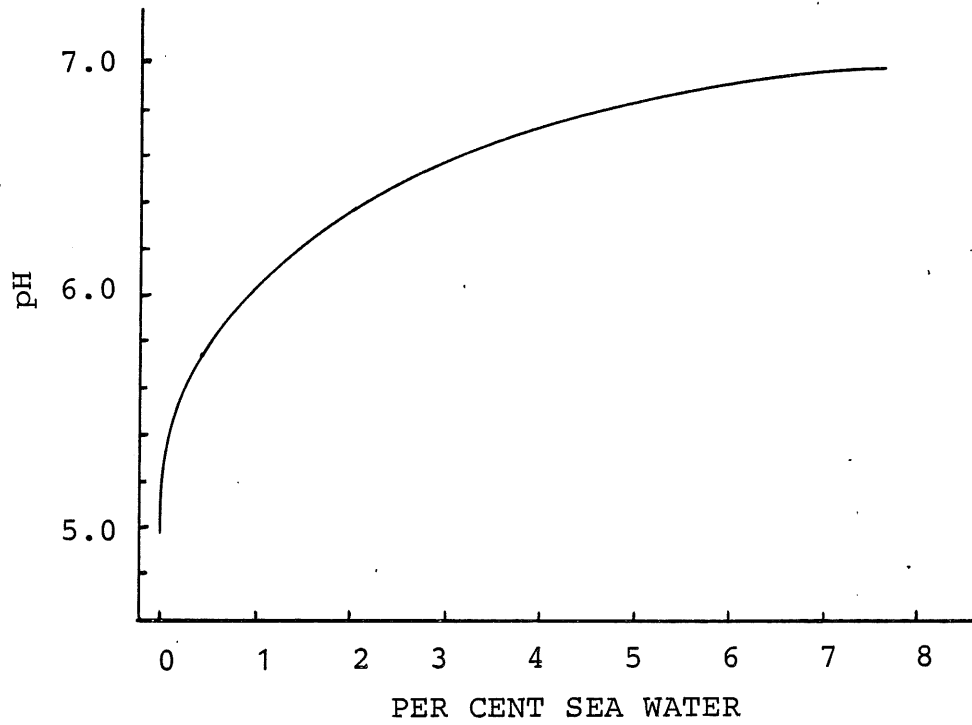


Fig. 1. The titration of acid river water with sea water of 30 ppt salinity.

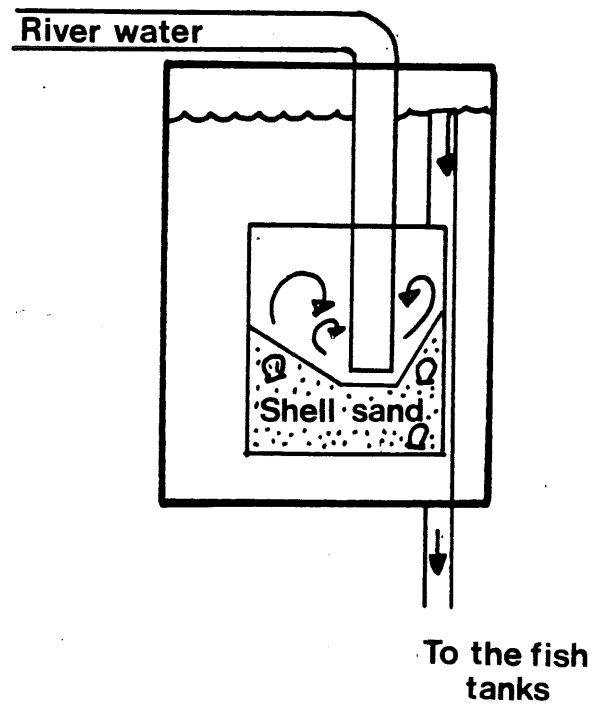


Fig. 2. A outline of the shell sand well.

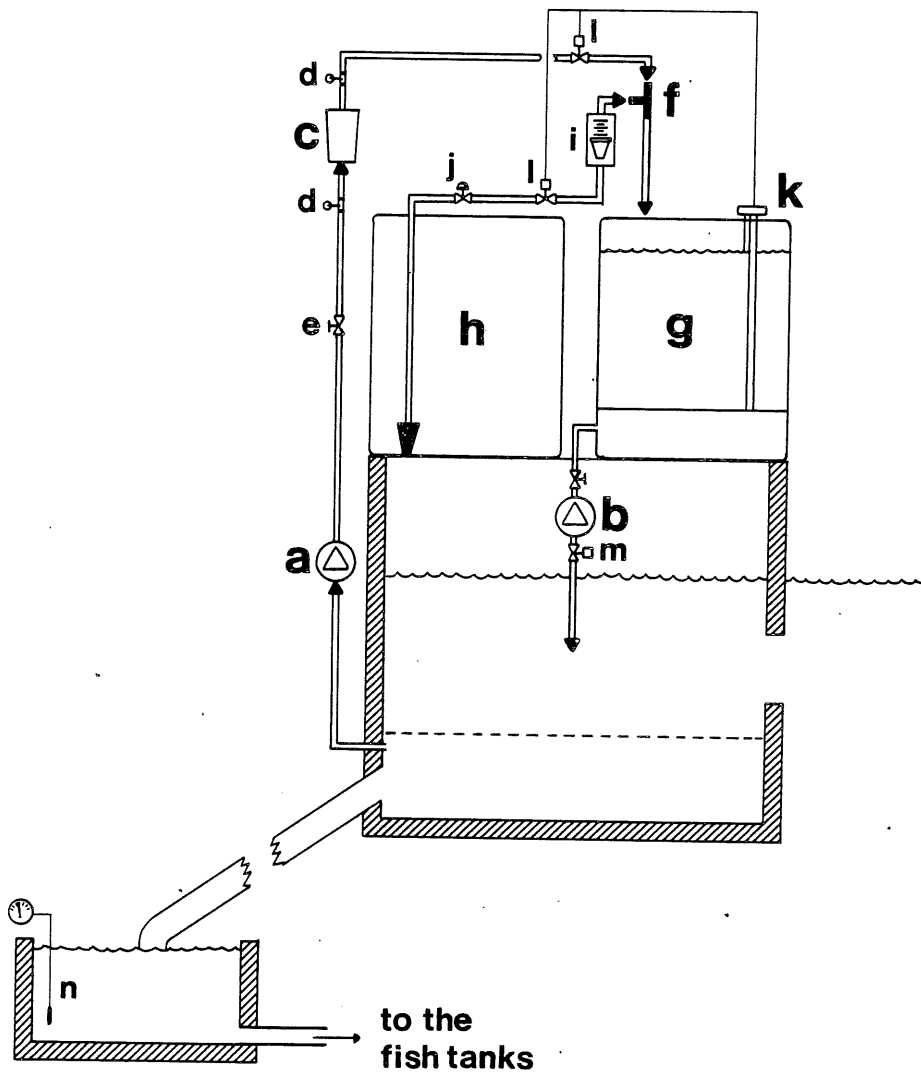


Fig. 3. Automatic system for neutralization of river water with sodium hydroxide. a and b, pumps; c, filtering unit; d, pressure gauges; e, stop cock; f, ejector; g and h, holding tanks; i, flow meter; j, stop valve; k, float switch; l, solenoid valves; m, counterpressure valve; n, electrode.

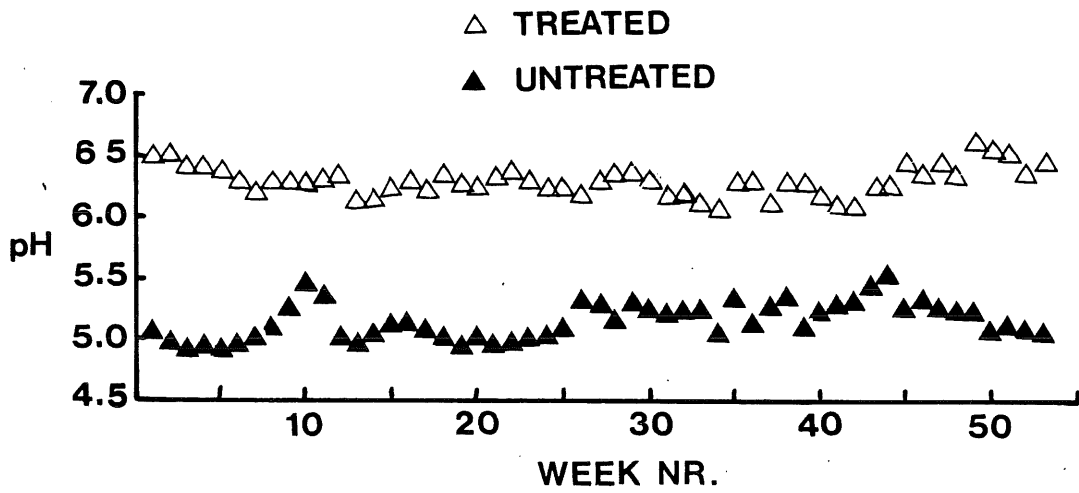


Fig. 4. Mean weekly pH of untreated river water and river water pH regulated with sodium hydroxide.

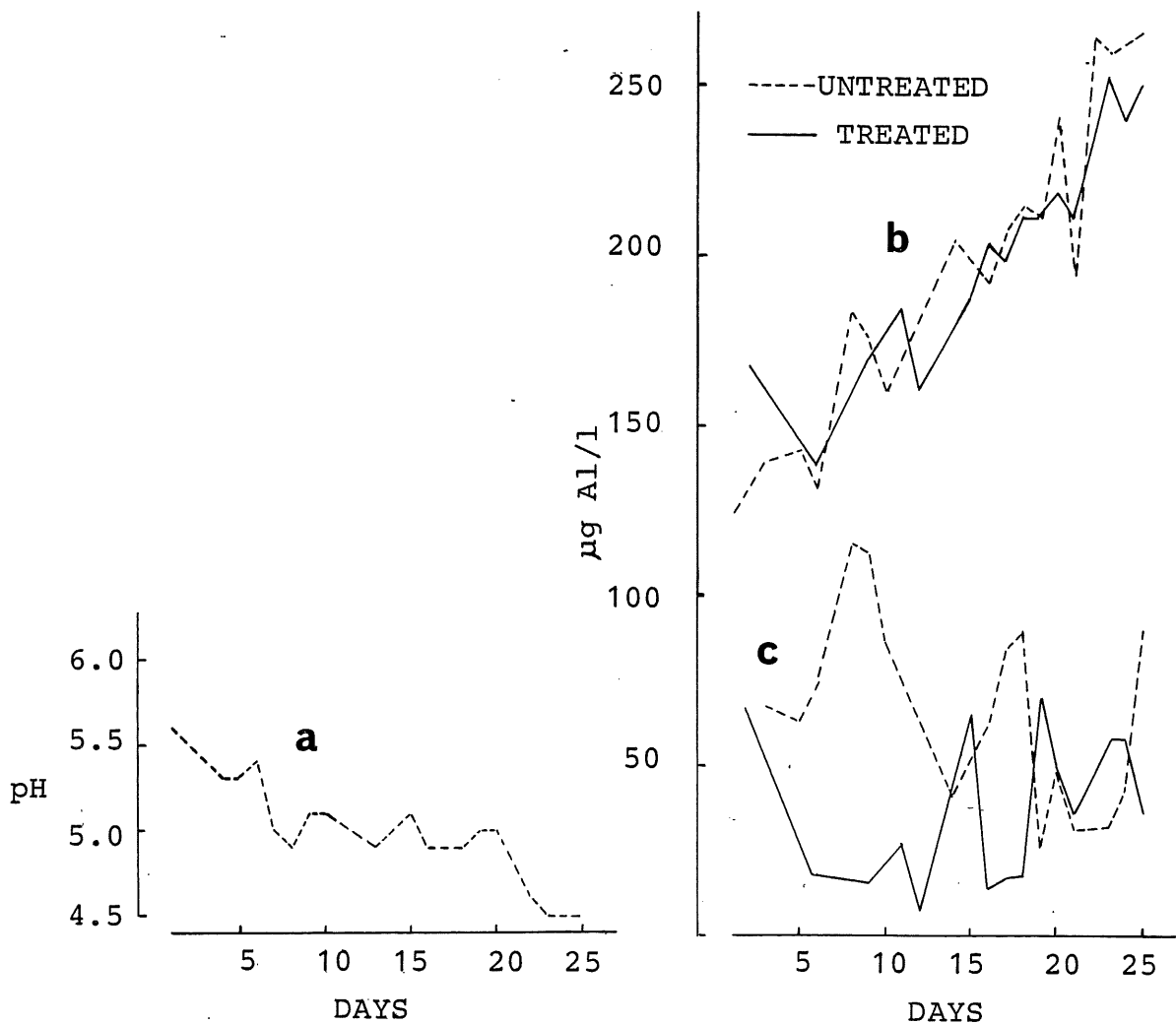


Fig. 5. pH in river water (a), total acid reactive (b) and labile aluminium (c) of untreated river water and river water pH regulated with sodium hydroxide during the snow melting period in april 1984.

