THE MAINTENANCE OF SATISFACTORY WATER CONDITIONS IN DOLPHINARIA

A.P.L. Wallis F.I.P.H.E., F.A.P.H.I.

Corporate Public Health Engineer. Honorary Consultant, Brighton. Aquarium, Brighton, Sussex, England.

Summary

The natural habitat of the dolphin has an in-built ability for self purification. As waste products are produced they are degraded and consumed by plankton, bacteria and fish so rejoining the food chain, the water remaining in a 'pure' state. These natural processes do not exist in closed dolphinaria and have to be replaced by mechanical and chemical processes evolved by man. Pollutants, including dolphin excrement must be continually removed from the water by efficient filter system and the use of chemicals such as chlorine which oxidises nitrogenous matter, coagulates fats and fish oils and disinfects the water. Rapid and continuous recycling of the water through the purification system is essential to maintain purity. It is important to extract foul water from the floor of the dolphin pool and from the surface where a bacteria, oil and mucoidal 'slick' collects.

In the new dolphin pool at Brighton Aquarium which has a capacity of 850 cubic metres and is capable of holding 6 or 8 dolphins, water is recycled every 2.25 hours. Liquid chlorine dosing has given way to in-situ production by electrolysis. This has eased maintenance and improved efficiency. 'Breakpoint', or high free chlorine residual, chlorination is practised and is found to be acceptable to dolphins.

The water purity standards recommended in the U.S.A. for oceanaria are inadequate to maintain the health of dolphins in the small volume dolphinaria found in Europe.

Introduction

The dolphin's natural habitat, is the sea, where the vast volumes of water and all the various forms of life it contains maintains the environment in a chemically and biologically balanced state. As waste products are produced they are immediately consumed or broken down by fish, plankton and bacterial life so that the sea remains in a so called 'pure' state.

However, when dolphins are maintained in a dolphinarium the natural balance of life in the water, viz., fish, plankton, algae, fungi and bacteria, is lost, and the duties these natural forms perform have to be undertaken by mechanical filters

and chemical processes devised by man. It is essential that the water is maintained in a 'pure' state as, like the human species, dolphins are subject to water transmissible disease, such as staphylococcal and streptococcal conjunctivitis, bronchitis, fungal skin disease, enteric infections due to the presence of *Salmonellae, Proteus morganii* and *Klebsiella;* also enteric parasites. The water has therefore to be purified in much the same way as that contained in a swimming pool. The techniques however are much more exacting, as dolphins remain immersed in the water at all times, and should not be subject to chemical or microbiological change outside certain parameters. Important factors are, the control of the pH of the water which if allowed to become too acid or too alkaline would lead to irritant conditions, the levels and nature of chlorine fractions used to kill bacteria, virus and fungi which cause disease; the levels of salinity and other dissolved salts which maintain the spectrum of microflora and osmotic balance. The remains of food, excreta, dead bacteria and all other flotsam must be removed by an efficient filtration system through which the water should be re-circulated at a rate relative to the dolphin/water gallonage ratio. Other processes sometimes required include 'polishing' and decolourisation to give the water super- clarity and appeal for the benefit of the viewing public. Alien life (i.e. pathogenic) is inactivated or destroyed by the use of chlorine and ozone. Fresh sea water required to make up the volume in the pool is often at a premium, because it is obtained in a very dirty state from the natural source under difficulty. To overcome this problem filters can be designed to reclaim the backwash water after flocculation thereby reducing the 'make-up' problem to the absolute minimum. Where 'artificial' sea water is used, an electronic alarm system should be installed to warn the operator of any fall-off in the level of total dissolved salts which might affect the health of the dolphins. As the dolphins' natural mode of feeding is lost in captivity, it is replaced by the supply of high quality dead fish fed at the rate of approximately 5/7 Kg (11/15 lbs) for each grown dolphin per day. Extra vitamins and essential minerals are added to the feed. Feeding results in the excretion of up to 7 Kg (15 lbs) of semi-liquid highly nitrogenous matter from each dolphin per day, and if allowed to remain in the water would soon result in the water turning septic and foul. Efficient water filtration, combined with chemical treatment, is as essential to the health of the dolphins as is the quality of the food they are given, and should be carried out under the general direction of a person competent in, and with a good understanding of, water purification techniques.

The basic criterion by which the health of dolphins can be judged is their vitality and obvious enjoyment in participation in the 'show', and play amongst themselves. Dull, listless creatures are a sign of ill health, which may be brought about by poor feeding or unsatisfactory water conditions (both aspects

are complementary) and in some instances accoustic pollution. The maintenance of clean, pure, and chemically balanced water is a guard against cross-infection in these valuable creatures, and pays handsome dividends being reflected in the superiority of their display.

The frequent excretions from dolphins and surplus food particles constantly foul the water in a dolphin pool. Heavy food particles drop to the floor of the pool, where they are unsightly deposits and would decompose if not drawn rapidly away to the water treatment plant for disposal. Main drain outlets should be designed to accommodate the heavy debris associated with dolphin pools. Fish oils and light particles form a 'slick' on the surface of the water, being a source of infection and spoiling the appearance of the pool unless there is constant extraction of this surface layer for treatment. The constant and efficient removal of surface 'slick' has produced problems for engineers for many years but many engineering companies now offer highly efficient surface water skimmers. These are hydraulically balanced water withdrawal units each capable of extracting 600 litres per hour (3,000 g.p.h.) and effective in skimming slick from up to 56 sq. metres (600 sq. feet) of pool surface area. Units can be plumbed in multiples, and are positioned to provide the most effective draw-off. Large debris such as fish particles and fish scales should be retained by coarse strainers prior to water reaching the filter media. Removal of heavy debris at this stage in treatment reduces the loading on filter beds, protects them from the 'blinding' effect of fish scale, and reduces the demand for chemical treatment if removed from the system at frequent intervals. The greatest hydraulic stresses of any system of recirculation are centred on the pump/motor units. It is essential therefore that these are manufactured to the highest degree of precision and of robust construction. It is essential that constant service be available so long as dolphins are present in the pool. A standby pump is essential to any facility of this nature, which not only provides freedom from anxiety in case of breakdown, but also allows regular inspection and maintenance to be carried out on either pump without disrupting services. Stainless steel or marine bronze pumps are an essential where waters having a high electrolytic potential (saline waters) are being re-circulated. Present day sophisticated plastics industry has produced ideal pipe materials and valve components which allow a corrosion-proof circulation system to be installed. Rigid P.V.C. and A.B.S. pipe systems provide low friction-flows, reducing the need for large diameter pipe installations and reducing overall costs. Lever handled butterfly valves reduce operation to a minimum and automated valve systems are available.

Both pressure and vacuum pre-coat (diatomite) filters are commonly used in the filtration of dolphin pool water. These units are also used to contain decolourising media.

Married to, and complementary to, water filtration is the chemical treatment

required to oxidise organic matter, inactivate or destroy harmful bacteria and other micro-organisms, to coagulate fats and oils present and make them filterable; so generally to maintain the water in a state of constant equilibrium somewhat on a par with what nature provides in the balanced processes of ecology. Where gaseous or alkaline chlorine reagents are used, there is a need to compensate for change in pH. In practice this proves to be an exacting science which is seldom carried out with accuracy under average operating conditions. A chlorinating system such as an electrochlorine cell which provides inherent pH control, is the more acceptable arrangement. Microscopic debris and particles of a gelatinous nature sometimes require coagulation before they become readily filterable — for this purpose a flocculent such as sulphate of alumina is frequently used.

The Dolphin Pool - Brighton Aquarium

The new dolphin pool at the Brighton Aquarium, Sussex, England, was constructed in 1968/1969 by the Cementation Company. It is a totally above ground structure formed in shuttered reinforced concrete and lined with a self coloured glass fibre epoxy resin finish. The pool is approximately 30 metres long, 10 metres wide and holding pens along one side 13 metres long and 4 metres wide. The whole pool including pens is 3 metres deep and has a capacity of 850 cu. metres (170,000 gallons) and is capable of maintaining 6 or 8 dolphins in a healthy state. The water treatment services were designed and supplied by Stanwell Filtration Ltd. and installed by Lamberts of Wolverhampton. Water is drawn from the pool via eight 0.5 m. (18″) square sumps and ten surface water skimmers. Trunk suction mains are in 200 mm. (8″) i.d. P.V.C. and all associated pipework is in the same material. Seventeen water inlets return purified water to the pool which together with the location of the sumps and surface water skimmers provides an ideally balanced flow of water throughout the pool.

The purification plant is served by 3 no: Worthington Simpson 17½ h.p. motor 4 DMC/94 close coupled stainless steel centrifugal pumps (2 operational; 1 standby) each capable of delivering 3.0 cu. metres (616 gallons) per minute against a head of 14.4 metres (57 ft.), in association with two 2.3 m (90″) diameter vertical sand filters passing 70 litres (14 gallons) per square foot per minute at optimum with a clean run differential of 0.3 Kg/cm^2 (4 lbs. per square inch) a flow of 371.280 cu. metres (74,256 gallons) per hour is achieved so providing a turnover of water in the pool every 2 hours 15 minutes. Plant is operated on a 24 hour basis so producing 9.6 turns of water each day. Large capacity strainer pots protect the pumps and collect fish scales and other gross debris.

Natural sea water is used in the pool which is taken from off Brighton beach

under favourable tidal conditions. Efficient water treatment plant has reduced the intake to a minimum which is currently at the rate of appoximately 1,000 gallons per day which replenishes water lost by evaporation and in backwashing filters. Some mains water is also used as a dilutent in stabilising salt levels. Kibbled Sulphate of Alumina is regularly used as a flocculent. The filters are backwashed on a daily basis, the backwash water being discharged into a 10.0 cu. metre (2,000 gallon) sump. The backwash water is allowed to settle overnight and the supernatant water taken back into the dolphin pool via the filters — this has proved to be a successful exercise which is particularly useful during periods of inclement weather when beach conditions make it impossible to take water direct from the sea.

In the normal course of events gas chlorination equipment would have been installed as a sterilising system. However, because of the adverse location of the plant room which made ventilation difficult it was found necessary to evolve an alternative safe system. Initially sodium hypochlorite solution was used, but because of difficulties in handling, metering and pH control, the system was disbanded and electrolytic equipment installed.

The present plate type cell (platinised titanium anode; mild steel cathode) was installed by Constructors John Brown Ltd. of Portsmouth, which operating on an 8 volt/500 amp rectifier is capable of producing ½ Kg (1 lb) of gaseous chlorine per hour. To begin with considerable difficulty was encountered with the production of hydrogen from the cathode which failed to vent to the open air and was carried into the filter tanks. This problem was overcome by revising the plumbing of the chlorinating system to discharge direct to the pool rather than into the suction lines leading to the filters. Important advantages of the electrolytic cell are low cost of chlorine (£ 60,00 per annum as opposed to £ 900,00 using sodium hijpochlorite) and inherent pH control.

Colour and organic adsorption has been enhanced by the occasional use of activated charcoal in the filter system. In order to avoid the fine charcoal bleeding through the sand into the pool the filter is just conditioned with a precoat of diatomaceous earth or Kieselguhr (Celite 545). This process, which was frequently necessary with following the installation of the electrolytic cell. Whilst the prime object of the cell is to produce chlorine the electrolytic process is more complex evolving the peroxides and ozone which have a beneficial effect on the quality of the water biocidal, anti-irritant, colour and odour control aspects. The overall efficiency of the water treatment system is such that debris does not build up in the dolphin pool and effective water recirculation together with vigorous agitation by the dolphins themselves ensure that the floor of the pool remains clean. No algal problems have arisen since 'breakpoint' chlorination techniques are employed with a free chlorine residual being maintained at 1.0 - 2.0 mg/L with a total chlorine residual of 1.5 - 3.0 mg/L. Experience

to date indicates that the dolphins are unaffected by this level of chlorination subject to correct pH control and efficient removal of nitrogenous wastes. Day to day water control is supported by colorimetric tests for free available chlorine and chloramines, pH meter readings and regular chemical and bacteriological water analysis. The dolphins themselves are subject to regular examination and treatment as necessary by a consultant veterinary surgeon.

Legislative and other controls

Very few zoos or aquaria provide water treatment for their mammals, relying for the most part on occasional water changes to maintain reasonable conditions. This situation has been severely criticised by a recent university and other groups concerned with animal conservation. With the current mode and interest in pollution the public in general has become aware of the dangers of unsatisfactory water conditions so far as animal life is concerned. There is however no legislative control over zoos or aquaria and much is left to the conscience of the management in maintaining their stock in healthy environments. Undoubtedly some form of control will come. With particular regard to dolphins, the Florida Department of Natural Resources has prepared a memorandum on the capture and maintenance of the species. In so far as water purification is concerned the memorandum relates the approved bacteriological standard to the U.S. bathing beaches standard setting a maximum average Coliform Density of 1,000 MPN/100 ml. and sets the following standards of chemical quality.

Salinity — 15 to 36 parts per thousand (15,000-36,000 mg/L).
Chlorine — A maximum of 0.3 mg/L (ppm) as free chlorine.
Copper — A maximum of 1.0 mg/L (ppm) as copper sulphate.
pH — 7.8 to 8.3.
Temperature should be between 40°F and 90°F.

The above provide very wide parameters within which to work other than for levels of free available chlorine and copper, and are correlated with vast volume oceanaria. These later two standards stand by to be challenged both on practical grounds and grounds of efficiency in small volume pools as constructed in Europe where pollution/volume ratio is more intense.

A much higher standard of water purification is aimed at in the Brighton pool where one would expect to find the more or less sterile water conditions associated with the 'breakpoint' chlorination technique. The salanity of the water obtained from the sea off Brighton is in the order of 28,000 mg/L with a pH of 7.8. The use of sulphate of alumina and the excretions of the dolphins tends to suppress pH and occasional dosing with sodium carbonate is required to counteract this.

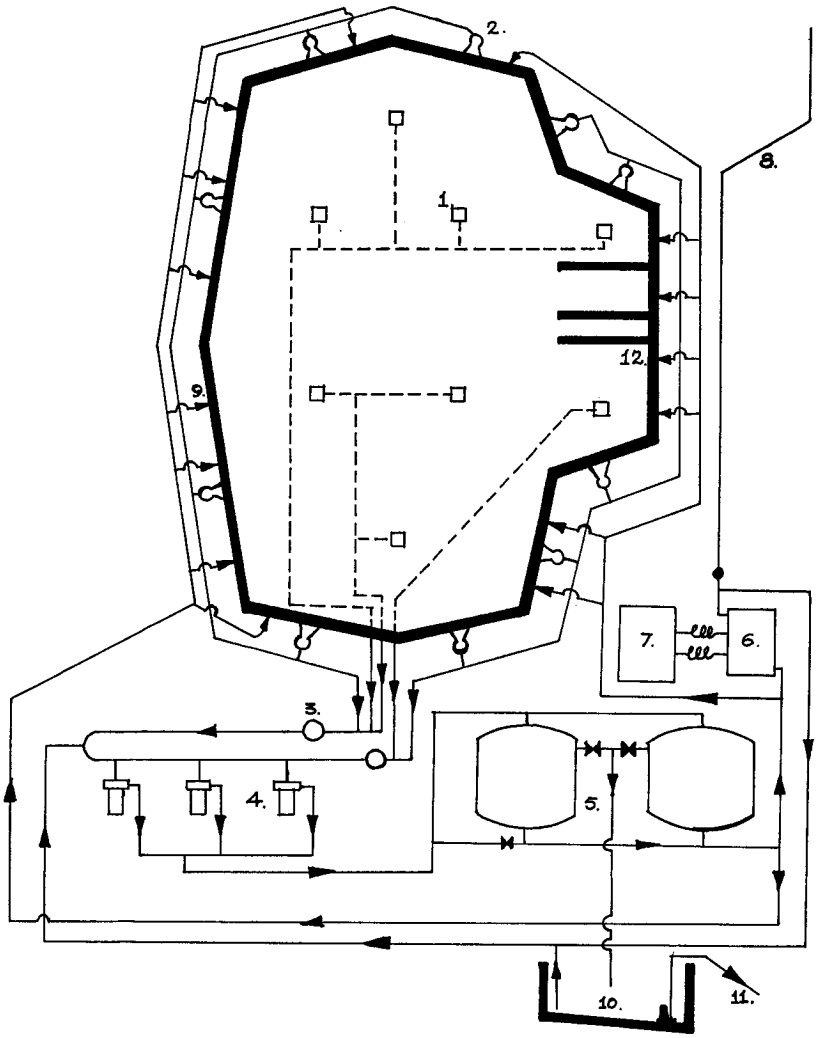

Figure 1 Schematic diagram of water purification system. Brighton Dolphinarium, England

KEY
1. Floor sumps
2. Surface water skimmers
3. Strainer pots
4. Pumps
5. Filters
6. Electro-chlorine- cell
7. Electricity rectifier 8 volts 500 amps
8. Hydrogen ventilation pipe
9. Water inlets
10. Filter backwash and water reclamation tank
11. Pump to drain
12. Holding pens