

OBSERVATIONS ON THE HYGIENIC CONDITION OF PUBLIC SWIMMING BATHS.

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INTRODUCTION.

THE value of swimming as a recreation has long been recognised in the physical training of children, since it provides not only a valuable form of exercise but also a tonic effect from bathing in cold water. When practised in the open, additional benefit is obtained from sunshine and fresh air, but unfortunately owing to the climatic conditions of the country open-air bathing can only be carried out in comfort for a limited period during the summer months. This has resulted in a demand for indoor swimming ponds where facilities can be obtained for bathing throughout the year, and most Local Authorities possess one or more of these baths. The majority of them are provided with fresh water from the main supply, but it is common to find that seaside communities frequently utilise sea water for their swimming ponds. In some localities, especially where the baths are of modern construction, filters have been installed to purify the water which, in addition, is aerated and chlorinated, but it is more often the case that the baths do not possess any means of purification and rely solely on emptying the pond and refilling with fresh water. In this system the frequency with which the water is changed usually depends on its appearance, and it should be pointed out that water which may appear clear can often be shown to be unsound by a bacteriological examination.

In the baths examined by the author this system of filling and emptying without chemical treatment of the water was employed, unless at a sea water bath, where the water is filtered before entering the pond. It should be noted, however, that the water although filtered is not chlorinated, but it is changed frequently and, in addition, an overflow of 20,000 gallons is added daily.

It is evident that the increase in the popularity of swimming has resulted in a greater use by the general public of both private and public swimming baths, and a growing interest is being manifested in the hygienic conditions of the ponds.

It is also increasingly common to find certain infectious conditions occurring after bathing attributed to contaminated water. References to infection occurring in this manner are not very numerous, but instances where the water

of swimming baths has acted as a medium for transmitting disease are quoted by various writers. Manheimer (1914) divides these into three classes: (1) intestinal infections, (2) infections of the eye and ear, (3) venereal disease.

This classification is rather inadequate in that it fails to include infections of the skin and naso-pharynx and also meningitis. The following summary outlines the investigations of authentic cases or epidemics of disease which have apparently resulted from the use of swimming pools.

INTESTINAL INFECTIONS.

These appear to have occurred through bathing in polluted rivers, or in swimming pools which derive their water from such rivers, and the cause of the disease has been due to general sewage pollution of the water rather than infection from bather to bather. Pfuhl (1888), Klein and Schultz (1898) and other writers have reported epidemics of typhoid fever which occurred in this manner, and Shiga in Japan reported an epidemic of dysentery which arose as a result of bathing in an infected river. More recently Reece (1908-9) described a small epidemic of enteric fever among soldiers who had bathed in a swimming pool filled with sea water drawn from an area in which sewage was discharged.

At the same time it should be noted that as well as typhoid fever and dysentery, intestinal infections of considerable severity supposed to be due to *B. proteus* have been recorded by Jäger (1892) and others. This is of special interest owing to the frequency with which this organism is found in the water (*vide* Tables I and II).

INFECTIONS OF THE EYE AND EAR.

Conjunctivitis appears to occur frequently in bathers and occasionally epidemics have been noted. Amersbach (1921) describes an outbreak of conjunctivitis and middle ear disease at Freiburg, and Schultz (1899) recorded eighteen cases of trachoma in men who used a swimming pool which had been contaminated by an attendant who had "sore eyes."

Disease of the middle ear occurring after bathing has been undoubtedly more often reported than any other infective condition, although the exact mode of infection is not known. It is possible that the water acts in a purely mechanical way by forcing the secretions from the nose and naso-pharynx into the Eustachian tubes, and the disease arises from an auto-inoculation of the middle ear with the organisms present in these secretions. On the other hand, if pyogenic organisms are present in the water, infection might possibly result from their introduction into the Eustachian tubes. Hasty (1927) found by injecting water from swimming pools directly into the middle ears of guinea-pigs that otitis media occurred in all the animals injected, and that cultures made from the infected ears showed several types of pyogenic bacteria. McKenzie (1921) in a letter to the *Lancet* states that cases of ear suppuration among bathers assumes an epidemic form every warm summer and that the infection is usually of a highly virulent type, often with serious sequelae.

Lloyd (1921) also reports the occurrence of cases of otitis media following visits to public swimming baths. One of the cases, a boy unaccustomed to bathing, developed earache after three visits to the baths and subsequently died of meningitis. More recently, Daggett and Cove-Smith (1929) have pointed out the dangers that follow bathing in public swimming baths. They consider that infected water may enter the middle ear through the Eustachian tubes and produce acute otitis media, and state that people who bathe in the sea or mountain rivers are usually exempt from trouble, while those who use public swimming ponds and "town rivers" are often affected.

It should be noted that although it has been customary to regard sea water as relatively free from bacteria and consequently safe to bathe in, many bacteria can survive for considerable periods in sea water, and the use of untreated water into which sewage is discharged must be regarded as a potential danger to the bathing public.

MENINGITIS AND POLIOMYELITIS.

Graham Forbes, Lloyd, and Cheatle in letters to the *Lancet* (1921) record meningitis as one of the fatal sequelae to ear disease contracted as a result of bathing, but there is no evidence that cerebro-spinal meningitis may be spread in this way. Two recent cases of this disease at Acton were alleged to have been contracted in swimming baths, but when enquired into the allegation was not substantiated (*vide Report of Ministry of Health on the Purification of the Water of Swimming Baths*, August, 1929). It is pointed out in that report that the meningococcus is a delicate organism which cannot survive long and which has never been isolated from bath water. This will be referred to later.

Batten (1911) was of the opinion that epidemic poliomyelitis might be transmitted by infected water in swimming ponds, but this has not been confirmed.

NASO-PHARYNGEAL AND RESPIRATORY INFECTIONS.

Nasal catarrh occurs frequently after bathing, but is probably due to prolonged immersion or chilling, allowing the organisms already present as commensals in the nasal secretions to set up a catarrh which may be followed by infection of the maxillary antrum. On the other hand, Hasty (1927) demonstrated that water reached the various parts of the nose by adding sterile powdered charcoal to the water of a pond before some boys bathed. After bathing each boy was found to have particles of charcoal in the nose, with a deposit on one side or other of the middle turbinate. It was found that the nasal mucous membrane was shrunken and bleached but later became congested and oedematous, and it was suggested that during the shrunken stage infected water may pass into the sinuses, and that the subsequent congestion prevents the escape of the bacteria which multiply and produce disease. McKenzie (1921) records a case of suppuration of the maxillary antrum, and quotes Hope (1914) as having reported several cases of this nature. In the

same way pneumonia, which has occasionally been attributed to bathing, may probably be due to a lowered resistance of the body creating the conditions necessary for an auto-infection to take place by pneumococci already present in the body.

VENEREAL DISEASE.

It appears that the risk of spread of venereal disease in public baths is limited to outbreaks of gonorrhoeal vulvovaginitis in children. Although it is recognised that the infection is most frequently spread by the use of common towels, lavatory seats, etc., it is also recorded that epidemics have occurred where the infection was undoubtedly spread by contaminated water. Suchard (1877) reported an epidemic in which the use of a common swimming bath was stated to be the mode of infection, and it is significant that the epidemic stopped as soon as the bath was disinfected.

Skutsch (1892) noted a similar epidemic which spread to 236 girls in a school at Posen. They had all used the same swimming pool but not the same towels, soap, etc., and it is interesting to note that a number of boys who also used the bath escaped infection. That gonococcal infection may be spread by the water of swimming baths has been demonstrated to be possible by Engering (1923), who found that gonococci lived in sterile tap water at 22° C. from 3 to 10 hours, depending on the strain of the organisms. He also found that the gonococcus kept alive in the surface water of a swimming bath for 7½ to 10 hours and in the deep water 8 to 14 hours.

It should be pointed out that infection by this organism from contaminated water has very rarely been recorded, and has never been found to occur in males or in females over the age of puberty. It also might be mentioned that there is no record of gonorrhoeal ophthalmia ever being contracted in baths, and since the conjunctiva is particularly vulnerable to the gonococcus it would appear that the risk of infection even in female children is very small.

SKIN INFECTION.

Many skin conditions have been associated frequently with the use of swimming ponds. Such conditions as pediculosis, scabies and ringworm are probably spread by towels, costumes, etc., and not by water. Rankin (1912) considers that *Molluscum contagiosum* is spread by the water, and this is confirmed by the experience of many skin specialists.

Bathing in infected water has been suspected occasionally of causing some other conditions, but the above appear to be the most commonly reported diseases which may arise as the result of using swimming baths. Graham Forbes (1927) quotes the results of a questionnaire issued in 1921 to 2000 medical practitioners by the Special Committee on Bathing Places of the American Public Health Association, and includes a list of diseases attributed by them to bathing.

AUTHOR'S OBSERVATIONS.

From the cases and epidemics recorded above, it is apparent that certain maladies have occurred through the use of swimming baths, and in some instances contaminated water appears to have been the immediate source of infection. In view of this it was thought advisable to undertake an investigation of the water of various swimming baths, not only to estimate the number of organisms present on each day of use, but also to ascertain the types of organisms and, more particularly, whether any pathogenic organisms could be isolated.

Samples were taken and examined immediately after the baths were filled and before bathing commenced, and the results found to approximate closely to those obtained from ordinary tap water. These samples were afterwards omitted and a specimen was taken each day while the pond was in use. The water used in the various baths, with the exception of one which contains sea water, is ordinary tap water as supplied for drinking purposes, and it is of interest for comparative purposes to quote the average results of a recent examination (September, 1929).

Total bacteria viable in agar at 37° C. = 4 per c.c.

Total bacteria viable in gelatin at 22° C. = 12 per c.c.

No *B. coli* present in 50 c.c. or smaller quantities of water.

Before discussing the results obtained in the daily examination of samples from the baths, it is necessary to indicate the routine measures employed at the various swimming ponds in the course of changing the water. All the fresh water baths are emptied and refilled once a week in winter and twice a week in summer, and the pond when empty is swabbed with chloride of lime and "gospo." There is no filtration or disinfection of the water. It should be noted that occasionally the water may be changed more frequently should the occasion arise (*i.e.* if the water becomes obviously dirty more quickly than is usual), and it is interesting to find that ponds reserved solely for female bathers become dirty in appearance more quickly than the men's pond as a result of dye coming out of the costumes. This is illustrated in the following table where the water in the women's pond was changed after the fourth day of use, while that in the men's was retained for six days as is usual during the winter months.

Table I gives the results of an examination which was made in November 1928 of the water at Bath "A." Specimens were taken immediately after the baths were filled and before bathing had commenced, and further samples were examined on successive days until the ponds were emptied and refilled with fresh water. The results obtained indicate that after the first day of use, bathers were swimming in water which can only be regarded as grossly polluted, since it contained not only an excessively large number of bacteria, but also *B. coli* in very small quantities of water, and in addition those types of organisms which are commonly present on the skin, in the

Table I.

Day of sample	Total viable bacteria per c.c.		Amount of water in which <i>B. coli</i> is present (c.c.)	Remarks		
	Agar at 37° C.	Gelatin at 20° C.				
Bath "A" Men	1st	2,925	2,510	+	<i>B. pyocaneus</i>	
	2nd	116,000	657,000	1-0	+	<i>B. subtilis</i>
	3rd	59,600	146,000	0-1	+	<i>B. wechii</i>
	4th	53,000	126,000	0-1	+	+
	5th	63,000	199,000	0-1	+	Enterococci
	6th	75,000	560,000	0-1	+	<i>Streptococcus salivarius</i>
Women	1st	2,110	7,170	10	+	Staphylococci
	2nd	99,800	150,000	0-1	+	<i>B. faecalis</i>
	3rd	44,000	185,800	0-1	+	Diphtheroid bacilli*
	4th	31,600	153,400	0-1	+	Atypical <i>B. dysenteriae</i>

* Diphtheroid bacilli were present on two occasions, but were too scanty to isolate in pure culture.

Table II.

Bath "A"	Capacity in gallons	Average daily attendance	Day of sample	Total viable bacteria per c.c.			Amount of water in which <i>B. coli</i> is present (c.c.)	Remarks
				Agar at 37° C.	Gelatin at 20° C.	Staphylococci		
Men	98,000	220	1st	1,440	4,970	1-0	Water appears dirty	
			2nd	18,600	28,900	0-1	Water very dirty—sediment at bottom	
			3rd	46,000	1,316,000	0-1	" "	
Women	35,000	100	1st	1,400	16,880	1-0	" "	
			2nd	26,400	52,000	0-1	" "	
Bath "B"	80,000	367	1st	520	940	1-0	Water appears dirty	
			2nd	9,500	23,900	0-1	Water dirty—sediment, etc.	
			3rd	17,000	242,000	0-1	" "	
Bath "C"	86,000	159	1st	4,200	16,240	1-0	Water appears dirty	
			2nd	29,220	225,200	0-1	Water very dirty—sediment, etc.	
			3rd	171,000	583,000	0-1	" "	
Bath "D"	86,000	257	1st	23,600	38,900	1-0	Water dirty—sediment, etc.	
			2nd	92,000	2,890,000	0-1	Water very dirty—sediment	
			3rd	310,000	2,770,000	0-1	" "	
Bath "E"	90,000	368	1st	9,920	25,400	0-5	Water dirty—slight sediment	
			2nd	82,560	992,000	0-1	Water very dirty—sediment	
			3rd	704,000	3,810,000	0-1	" "	
Bath "F" (sea water)	86,000	422	1st	5,920	24,000	0-5	Water appears dirty	
			2nd	16,200	183,600	0-1	" "	

mouth, nose and throat, and in urine and excretal matter. It is also important to note that on one occasion an atypical *B. dysenteriae* was isolated and on two occasions diphtheroid bacilli were present in the water.

The water was re-examined during the summer months and the results of samples taken from Bath "A" and other baths are shown in Table II.

The samples in Table II were taken on the first day of bathing during the afternoon while the ponds were in use, and at a similar time each day until they were emptied, the water being changed twice weekly except at Bath "F" and in the women's pond at Bath "A" where it was renewed after two days.

Here again it is apparent that after the first day of use the water in the various baths showed evidence of serious pollution, and if the results are interpreted according to the standards for drinking water there can be no doubt that the water must be immediately condemned as unhygienic. When one considers the frequency with which water enters the mouth, nose and throat of bathers while swimming, and that bathers may inadvertently swallow a mouthful, the necessity becomes evident of interpreting a bacteriological analysis of swimming-bath water according to the standards of a drinking water.

From the hygienic standpoint the routine bacteriological examination of drinking water consists of the determination of the total viable bacteria in the specimen, and the quantitative examination of the water for *B. coli*. The latter is recognised to represent a reliable indication of recent excretal contamination, while the total bacterial count, although of little value by itself, may be useful in supplementing this test. The presence of faecal streptococci and sporing anaerobic bacilli is additional evidence of excretal pollution, while the demonstration of pathogenic bacteria in the water is, of course, absolute proof of serious contamination. Pathogenic organisms are, however, rarely found in the course of a water examination, either on account of the great dilution rendering them too scanty in a specimen to be isolated or owing to the short time in which most of them remain viable at low temperatures. It is customary therefore to assess results on the presence or absence of *B. coli* in various quantities of water, taking into consideration the total bacterial count and the presence or absence of faecal streptococci and other organisms. Recently, Mallman (1928) found that *B. coli* were capable of multiplying rapidly during the night in the water of swimming baths while streptococci were not, and concluded that the presence of the latter organism was a more reliable indication of intestinal pollution than *B. coli*.

If the results tabulated in Tables I and II are judged accordingly, it is seen that the water after the first day of use in each of the baths falls very far short of the required standard, and that even the water during the first day of bathing must be regarded as unhygienic.

In the examination of the samples a particular effort was made to isolate, if possible, any pathogenic organisms present in the water, and cultures were

made in suitable selective media. With the exception of staphylococci and the atypical *B. dysenteriae* isolated from Bath "A," the organisms which were found were of types which are not usually primary agents in infective conditions. It should be mentioned that the diphtheroid bacilli met with were too scanty to isolate in pure culture for complete identification. It might be said, therefore, that although the results revealed the presence in the water of large numbers of bacteria the majority of which were not pathogenic, the pollution was not of itself dangerous to the health of bathers. It should

Table III.

	Plated immediately	24 hrs	48 hrs	72 hrs	96 hrs	120 hrs	144 hrs
Staphylococci	+	+	+	+	+	+	+
Haemolytic streptococcus (Scarlatina)	+	+	+	+	+	+	+
Meningococci	+	-	-	-	-	-	-
Gonococci	+	-	-	-	-	-	-
Pneumococci	+	+	+	+	+	+	+
<i>B. diphtheriae</i>	+	+	+	+	-	-	-
<i>B. typhosus</i>	+	+	+	+	+	+	+

+ = growth on subculture at 37° C.
 - = no growth on subculture at 37° C.

be remembered, however, that the organisms isolated were types able to survive in water for a considerable period, and other more delicate pathogenic organisms may have been present but escaped detection among the more vegetable bacteria, or may have been originally present in the water but failed to survive at low temperature. This is illustrated by the following experiment. A number of pure cultures grown for 24 hours on slopes of blood or ordinary agar were added to sterile tap water (in the proportion of one slope to 300 c.c. of water) at room temperature and subcultures were made daily for six days. The water was kept at a temperature of 22° C. and quantities of 25 c.c. were centrifuged and the deposit inoculated on to suitable media. The results are indicated in Table III.

It was found that meningococci and gonococci did not survive for 24 hours and the experiment was repeated with these organisms, subcultures being made from the water at half-hourly intervals.

Table IV.

	Plated immediately	½ hr	1 hr	1½ hrs	2 hrs	2½ hrs
Meningococci	+	+	+	+	+ sc.	-
Gonococci	+	+	+	+ sc.	-	-

+ = growth on subculture.
 + sc. = growth present but very scanty.
 - = no growth.

The results recorded in Table IV show that neither meningococci nor gonococci survived more than 2½ hours in water at 22° C. and indicate that infection must take place within this time after the organisms are introduced into the water. Engering working with the gonococcus found that it survived

from 3 to 10 hours depending on the strain of organism, but it should be noted that the results in Table IV apply to laboratory cultures, and that gonococci and meningococci introduced into the water in pus or nasal secretions may have an entirely different period of survival.

It is thus possible for even very delicate pathogenic organisms when introduced into the water of swimming baths to remain viable for a period sufficiently long for infection to take place. The great dilution of the infecting material which is bound to occur is probably responsible for the infrequency with which disease is spread amongst bathers, and is responsible also in part for the difficulty in isolating pathogenic bacteria by ordinary bacteriological methods. Another difficulty encountered is the rapidity with which the saprophytic organisms grow at the expense of the more delicate pathogens. This was met with in the experiment recorded in Table III which was originally carried out with ordinary unsterilised tap water. It was quickly found that the bacteria ordinarily present in the water soon outgrew the particular organisms added, so that in 48 hours the pathogenic bacteria could only be isolated with great difficulty.

SOURCES OF CONTAMINATION.

Before discussing the recommendation of any methods which might be used to prevent the bacterial pollution of water in swimming baths, it is necessary to refer to the sources of this contamination.

Water.

The water used in filling the baths is usually pure and as a rule is ordinary drinking water, but it should be remembered that many sea water baths derive their water from areas adjacent to sewage outflows and may not receive the necessary treatment to render it safe to bathe in. Such sewage contamination, no matter how slight, must be regarded as a potential source of danger.

At the pond.

Atmospheric pollution is mainly responsible for the scum present in the surface of the water. This is most frequently found in baths situated in industrial districts, where dust and soot blow in through the windows, and although this makes the water unattractive to swim in, it does not of itself create serious pollution. Some deposit may occur at the bottom but this is mainly the result of mud and dirt carried in from the street by the boots of bathers and washed into the water from the sides of the pond.

A large amount of pollution is derived from bathing costumes. This is more obvious in ponds reserved solely for female bathers when the water rapidly changes colour from the addition of the dye. It has been found also that unless costumes are properly washed and disinfected they contain large numbers of bacteria (*vide Ministry of Health Report*).

The most serious pollution, however, comes from the bathers and is derived from the skin, hair and mucous membranes in the form of secretions from the mouth, nose and throat; dirt, sweat and desquamated epithelium from the skin, and in the form of excretions due to objectionable habits or involuntary actions of the bathers. It should also be remembered that bathers with "colds," septic cuts, infective skin and other conditions all add infectious matter to the water.

The results recorded in Tables I and II (pp. 71, 72) indicate that serious pollution of the water takes place from the above sources in a very short time, and moreover show that the method of emptying and refilling swimming ponds at frequent intervals does not keep the water at a standard of bacteriological purity comparable with that of a potable water. This has been overcome in many localities by the installation of filters through which the water is constantly passed, and is at the same time aerated and chlorinated. This, however, is not sufficient to maintain the purity of the water and it has been found necessary to prevent as far as possible the entrance of dirt to the ponds.

In order to minimise the inevitable contamination of swimming-bath water the Committee of the American Public Health Association (1926) issued the following recommendations. It should be noted that most of the American swimming baths are of modern construction, and the water is subjected to a continuous process of chlorination and filtration.

Scum gutters.

These should extend completely round the pool, and be designed so that matter entering will not be swept out by a surge of water. The edge to serve as a handhold, and drainage outlets should be every 10 feet. All scum gutters should be recessed into the pool wall.

Showers and toilets.

Showers. Minimum should be 1-40 bathers expected at time of maximum load (if mixed bathing, 2-3 men).

Toilet. 1 per 40 women. 1 and 1 urinal per 60 men.

Heating.

Water should not be below 70° nor above 75° F.

Suits, towels, etc.

It is desirable that suits and towels should be supplied and cared for by the management. If individually owned, they should be laundered and stored by the management.

Supervision.

There should be an attendant in the shower room or the entrance to the pool to inspect bathers for skin disease.

Personal regulations.

(1) All persons must be required to take a cleansing bath in the nude before bathing.

(2) Bathers leaving the pool room to use the toilet are required to take a second cleansing bath before returning to the pool.

(3) Bathers should be instructed to use the toilet and empty the bladder before taking a cleansing bath and entering the pool.

(4) Any person with skin disease, sore or inflamed eyes, cold, nasal or ear discharges, or any communicable disease must be excluded.

(5) Persons with burns, cuts, etc., should be warned about possible infection and be advised not to use the pool.

(6) Spitting, spouting of water, blowing of nose, etc., in the pool should be strictly prohibited. Scum gutters are provided for expectoration.

(7) Bathers should be instructed that blowing of the nose to remove water is likely to force infectious matter into sinuses and inner ear cavities.

(8) Divers should be advised to wear rubber caps over the ears or to plug the ears with greased cotton wool.

Bacteriological quality.

Bacterial count on agar, 2 days at 20° C. (optional). Not more than 10 per cent. of samples covering any considerable period shall contain more than 100 bacteria per c.c. No single sample shall contain more than 200 bacteria per c.c.

Bacterial count on agar, 24 hours at 37° C. Not more than 10 per cent. of samples shall contain more than 1000 bacteria per c.c. No single sample shall contain more than 5000 bacteria per c.c.

B. coli content (presumptive test). Not more than two out of five samples of 10 c.c. each, collected on the same day; or not more than three out of ten consecutive samples collected on different days shall show a positive presumptive test.

Cleaning pool.

(1) Visible dirt on the bottom should not be permitted to remain more than 24 hours.

(2) Visible scum on the surface to be removed within 24 hours.

Bathing load limits.

(1) Total number of bathers during any period of time should not exceed 20 persons per 1000 gallons of clean water added to the pool during that period.

(2) *Frequency of disinfection.* Total number of bathers permitted to use the pool during any period of time shall not exceed seven persons for each 1000 gallons, unless the pool shall have been completely disinfected at least once during that period.

SUMMARY AND CONCLUSIONS.

It is an undisputed fact that various diseases have been transmitted by the water of swimming baths, and although such cases have not been very frequently recorded it is nevertheless important that steps should be taken to prevent their occurrence. This can only be done by maintaining a standard of purity of the bath water similar to drinking water.

It is evident that the water of swimming ponds cannot be kept pure by the fill and empty system, but should be subjected to a process of continuous filtration combined with aeration and chlorination.

In order to maintain the standard of purity thus obtained it is necessary that a strict supervision should be made of the bathers, and those who have any infectious condition should not be permitted to use the pond.

Regulations similar to those suggested by the American Public Health Association should be made and enforced.

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