The theory of colors of water in the swimming pool

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1. Introduction: The color of water in the swimming pool varies from sky blue to green due to varying of refractive index with the contents of soluble calcium ion in the water. The more the soluble calcium is in the water, the more the tendency of water to be blue color. In the spectrum of light (figure 1) the green color is adjacent to blue color. Since water is losing calcium ion gradually by carbon dioxide from the air dissolved into the water, thus, the color of water will be gradually changed from sky blue to green when the water is exposed to the air or before and after the rain when the atmospheric pressure was increased, making more carbon dioxide dissolved into the water. The pH and alkalinity of water drops down and the water becomes more opaque due to calcium bicarbonate salt suspended in the water. When the water which turns green was left untreated for about two weeks its color will be changed to cloudy pale green because of calcium bicarbonate and calcium carbonate salts suspended in the water which is misunderstood as algae.

Violet: Indigo: **Blue: Green:**Yellow:Orange: Red

Figure 1. In the spectrum of light, blue and green are adjacent. The color of water in the swimming pool will gradually change from blue to green when the soluble calcium ion in the water drops down because of carbon dioxide in the air dissolved into the water.

Another cause of changing of color of water in the swimming pool from sky blue to green relates to the iron ions and rust in the make up water. Iron ions and rust in the make up water have yellow color by nature. Thus, when the make up water containing iron ions or rust is added into the swimming pool water to replace overflow and evaporation, the sky blue color of water in the swimming pool will be changed to green (Figure 2).

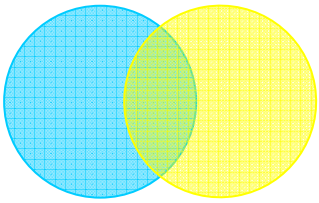

Figure 2. Sky blue water when contaminated with Yellow iron ions or rust gets Green water.

Iron ions in the make up water have two forms. The first is ferrous ion (Fe^{+2}) which is colorless and the second is ferric ion (Fe^{+3}) which is yellow color. The ferrous ion when contacted with oxygen or residual chlorine in the swimming pool water becomes ferric ion. Thus, even with colorless make up water, the color of swimming pool water may be eventually turns green because of ferrous ion in the make up water will gradually becomes ferric ion when contact with oxygen and residual chlorine. Ferrous ion comes mainly from deep well water which is usually mixed with tap water during dry seasons

when the supply of surface water is short, while ferric ion comes mainly from surface water or rust in the pipe lines, pumps or storage tanks. The concentration of iron ions in the water which makes the sky blue color of water turned green is very small, i.e., in the parts per billion (ppb) order of magnitude which is out of the range of common test kits. However, we can check if the tap water contains iron ions or rust or not by investigating the white color bathtub filled with tap water or concrete storage tank laid with white color tiles and the inside of storage tank of the toilet. If the color of water in the bathtub or storage tank is pale green then the tap water surely contains iron ions or rust. If it is sky blue then the tap water has no iron ions at that investigation period. The storage tank of toilet is too small to observer the color of water inside it. But it keeps the history of tap water over a long period. So, if the color of the wetted part inside the storage tank is brown with soil on the surface then the tap water surely contains iron ions or rust over a long period. Meaning, although there are no iron ions or rust in the tap water during investigation period, they existed in other periods of the year.

Although very small amount of ferric salts in the water may not cause the color of water to turn green as seen from the side of the pool explicitly, it makes a big difference to some divers. Some divers noticed that water in some swimming pool is so clear that when they dived on one side of the pool and looked through the water to the far side of the pool they could see the tiles on that far side clearly while in other swimming pools they could not. As a matter of fact, most of the above mentioned calcium salts and ferric salts once occurred cannot be filtered out by sand filters or diatomaceous earth filters used in the swimming pools. In section 3, we will talk about how to make such "super-clear" water for swimming pool.

2. Method of Treatment

Tap water filled into an empty swimming pool also needs treatment because the color of water will be pale green or cloudy pale blue and unclear. The same method of treatment is used to adjust the existing ordinary swimming pool water which is not blue, or green and unclear to become blue crystal clear.

2.1) Preparation of chemicals, test kits, tools and equipment

(For about 600 cubic meters swimming pool or 12.5 x 25 m2 x 2 m depth)

(1) Chemicals :
- 100 kg. of calcium hydroxide powder or lime (used in construction)
- 60 kg. of 33 % hydrochloric acid (conc.)
- 500 ml. of concentrated ammonia water as first aid in case of breathing hydrochloric acid fume.

(2) Test kits :
- Ordinary swimming pool test kits for pH and chlorine (only pH is used)

(3) Tools :
- 2 units of 20 liters plastic bins
- Acid protection mask with goggle inclusive
- Plastic gloves
- Vacuum head roller, long stick and flexible tube ordinarily used in cleaning the floor of swimming pool

(4) Equipment :
- Fill in make-up water until the pool is full and stop
- Backwash the filters
- Stop pumps
- Manipulate valves in such a way that no water is drained away from the pool
- Check underwater lamps. Turn them on in case of working at night.

2.2) Procedure of Treatment

(1) Blend 5 kg. of lime powder with 10 liters of tap water in a 20 liters bin. Stir it with hand which wears plastic glove.

(2) Pour the milky slurry part of liquid from the bin into the swimming pool, leaving the solid part precipitated at the bottom of the bin. Throw the precipitate away in another empty bin. The slurry should be poured throughout the pool evenly not at one spot.

(3) Repeat step 2 until 50 kilograms of lime powder is used. Wait for 15 minutes.

(4) Check pH of water. If the pH is lower than 10.5 then repeat step 2 again and again and check pH from time to time. When the pH is over 10.5 stop.

(5) Turn off the underwater lamps and let the water still for at least 6 hours.

(6) Return and put on the acid protection mask. Pour 20 kg. of 33% hydrochloric acid gradually into the pool evenly around the pool, not at one spot. Leaving for 10 minutes, no need to stir.

(7) Check pH of water. The pH of water will drop down. If the pH is over to 8.5, then pour 10 kg. of 33% hydrochloric acid into the pool gradually, wait 5 minutes. The hydrochloric acid should be poured throughout the pool evenly not at one spot.

(8) Repeat step 7 until the pH of water is 8.5 then stop. It is crucial not to bring the pH down below 8.5 or else the procedure must be repeated.

(9) Manipulate valves in such a way that the wastewater from the vacuum head roller will be drained away without passing through the filters. Start pump(s).

(10) Clean the floor of the pool with vacuum until finish.

(11) Manipulate valves in such a way that the make up water is filled in while the pumps are running to circulate water through the filters.

(12) After a few rounds of circulation time (1 round of circulation time = volume of water in the pool / pumping capacity), the water will be blue crystal clear.

Notes: a) Handle 33% hydrochloric acid with extreme care. Do not stand down stream to the wind with respect to the 33% hydrochloric acid or breath hydrochloric acid fume. In case of breathing a lot of hydrochloric acid fume, use cotton wool or cloth moistened with ammonia water to inhale slowly.

b) Theoretically 98% sulphuric acid should not be used in place of 33% hydrochloric acid because 98% sulphuric acid has high density. Once pour into the pool it will sink down to the bottom of the pool and will destroy the pool floor. Besides, the calcium sulphate salt resulting from the reactions with lime does not dissolve in water in that **salinity** range**.** Thus, theoretically, <u>in fresh water</u> sulphuric acid could not make the color of water blue but cloudy.

c) The pool is already in service at pH of 8.5 which is the highest value of pH allowed. We may add chlorine to the water at this moment. The pH of water will drop down gradually when there is make up water entering into the pool or carbon dioxide in the air is dissolved into the water. In case that pH between 7.2 to 7.8 range is strictly applied to that pool, simply pour 5 kg of 33% hydrochloric acid into the pool (when there is no one in the pool) and around the pool and check pH. Repeat this step carefully using 2-3 kg of 33% hydrochloric acid until the pH of water is 7.8 and stop. You can notice that the color of water is not as blue as at pH of 8.5

d) In some countries where copper sulphate (crystal) is allowed to be used in the swimming pools to protect algae due to high pH of water in the pool, it is recommended that 1 gram per cubic meter of copper sulphate is used and not more than 2 grams per cubic meter. Using copper sulphate will make the color of water be more blue. Do not use copper sulphate to adjust the color of water

in the swimming pool. Copper of more than 2 gram per cubic meter is reported to be dangerous to our health.

3. Making Super-Clear Water for Swimming Pool

3.1) Criteria

(1) For swimming pool with sand filters

- Remove iron ions, iron salts and rust from the swimming pool water.

(2) For swimming pool with diatomaceous filters

- Remove iron ions from the make up water.

3.2) Method : For swimming pool with sand filters

(1) Replace half of sand media in the sand filters by "Green Sand". Green sand is used in water treatment for removal of ferrous ion from the water. Green sand mentioned here has dark violet to black color. It is as fine as sand but not as round. Green sand which has pale brown color should not be used. But if necessary, wash it well before use because it is full of dust and silt. Backwash the filters well after replacing half of each sand filter with green sand. Use the filters as usual.

(2) Each and every day pour 1 - 2 grams of potassium permanganate ($KMnO_4$) into the swimming pool (when there is no one in the pool) 6 -12 hours before daily backwashing of the filters. The color of water will be pale violet because of the color of potassium permanganate and will turn to blue crystal clear again when the water has been filtered. The purpose of potassium permanganate is to regenerate the green sand inside the filters.

3.3) Method : For swimming pool with diatomaceous earth filters

Install a green sand filter or iron removal filter to the make up water supply line. Regeneration of green sand is done by means of dosing pump which injects potassium permanganate solution directly into the filter.

Remarks: 1) If a lot of potassium permanganate is dumped into the swimming pool water by accident making the color of water violet, to remedy, then pour sodium sulphite (Na_2SO_3) powder about 5 times as much as potassium permanganate into the swimming pool while the circulating pumps are on. Wait until the color of water turns pale yellow. Then, start the procedure in section 2 above and the water will become blue crystal clear.
2) Swimming pools which employ sand filters should used the method in item 3.3 too.

4. Sea Water Swimming Pool

The same procedure in section 2 can also be used but the quantity of calcium hydroxide or lime needed is much higher depending on total hardness of the sea water. For sea water of total hardness about 6,000 mg/l, the quantity of lime required would be about 3,000 kg for the sea water swimming pool of the size in section 2. This procedure is inevitably needed for initial treatment of all sea water pools, or otherwise precipitation will occur slowly and continuously making the water unclear and the pool floor and side walls become dirty repeatedly after cleaning because of carbon dioxide in the air reacts with minerals in the sea water forming precipitating salts which is misunderstood as microorganisms or planktons needed to be killed by disinfectants.

The Author
Sahatchai Wanawongsawad, 49, holds a BS degree in physics from Mahidol University in Bangkok. After graduation in 1978, he worked mainly in the field of water treatment with several companies. Presently, he works as a freelance English – Thai document translator at home. He has been spending his free time as an amateur mathematician on projective geometry and distribution & probability of non-equilibrium systems since 1975. He is glad to answer any question about water treatment in every field of application. His e-mail address is sahatchaiw@yahoo.com