

Hydrangea Flower- A Natural pH Indicator

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Hydrangea, *Hydrangea macrophylla* (commonly named as the hortensia, is a genus of more than 70 species of flowering plants native to Asia and the Americas. Most are shrubs 1–3 m (3 ft 3 inch – 9 ft 10 inch) tall, but some are small trees, and others lianas reach up to 30 m (100 ft) by climbing up trees. They can be either deciduous or evergreen, though the widely cultivated temperate species are all deciduous. Due to their versatility and ability to thrive in various zones, hydrangeas are a popular choice for home gardens as well as popular landscape plants in coastal areas. Hydrangea, native to Asia and the Americas, is one of the most popular and widely grown and marketed plants in the nursery and floriculture industry, owing to its beautiful flowers that come in a variety of shapes, colors, and sizes. Hydrangeas are popular shrubs with colourful flowers that bloom through summer and into fall. They usually bloom in shades of blue, purple, and pink, with some selections in white, green, or red. Most hydrangea bushes are easy to grow in Zones 3-9 and prefer partial shade. There are numerous species of deciduous and evergreen hydrangea shrubs, small trees, and climbers, which include approximately 1000 cultivars and hybrids (Fulcher *et al.* 2020). Many new selections are introduced annually worldwide due to their increasing popularity. Hydrangea flowers are produced from early spring to late autumn; they grow in flowerheads (corymbs or panicles) most often at the ends of the stems.

Hydrangeas are the natural indicators that can also tell you whether something is acidic or basic. Hydrangeas turn blue in acidic soil, purple in neutral soil, and pink in basic soil.

Hydrangeas come in several varieties. It's not every hydrangea that changes color. It's the flowers of some Bigleaf hydrangeas (*H. macrophylla*) – especially Mophead and Lacecap types and *H. serrata* cultivars whose colors change based on the pH of the soil.

Mophead hydrangeas are the most popular and come in different colors, including white. The flowers of many hydrangeas act as natural pH

indicators, sporting blue flowers when the soil is acidic and pink ones when the soil is alkaline. White flowers do not react to the pH of the soil; there is no way to alter their natural color outside of dyeing the plant. Pink and blue varieties, however, can be changed, and the color of these blossoms is directly related to the pH of the soil. Blue flowers indicate acidic soil while pink flowers indicate alkaline. Some other plants can be used as pH indicators for solutions, like red cabbage and butterfly pea flowers. But hydrangeas are the only plant that changes color based on soil pH. That is important because the blossom color will give you an idea of what other kinds of plants you can grow in your soil. They are water-demanding plants and are best suited for moderate water-use landscape zones.

Why do hydrangea flowers change color according to soil pH?

Most major plant nutrients are more accessible at a pH of 6 to 6.5. A pH that is too high or too low can keep plants from absorbing nutrients from the soil. The nutrients are unavailable or not absorbable to the plant because of soil's chemistry. This problem can manifest itself in a variety of ways, but in the case of hydrangeas, the bloom color changes. Color variation in hydrangeas is due to the presence or absence of aluminium compounds in the flowers. If aluminium is present, the color is blue. If it is present in small quantities, the color is variable between pink and blue. If aluminium is absent, the flowers are pink. Soil pH indirectly changes flower color by affecting the availability of aluminium in the soil. When the soil is acidic (pH 5.5 or lower), aluminium is more available to the roots, resulting in blue flowers. Hydrangeas respond to several, light applications of fertilizer during the growing season.

Traditional production of potted hydrangeas with blue flowers involves the use of water-soluble aluminium sulphate to cause the blue pigmentation of flower sepals. This technique has proved very effective for over a century but presents some problems related to high leachability in a greenhouse environment. Innovations in controlled release

technology already in use in the fertilizer industry are now being applied to the niche market of blue hydrangea production promising to nearly eliminate the problems with conventional aluminium sulphate applications.

Colors variability depends on soil conditions

Hydrangea flower color can change based on the pH in soil. As the graph depicts, soil with a pH of 5.5 or lower will produce blue flowers, a pH of 6.5 or higher will produce pink hydrangeas, and soil in between 5.5 and 6.5 will have purple hydrangeas. White hydrangeas cannot be color-manipulated by soil pH because they do not produce pigment for color. In other words, while the hue of the inflorescence is variable and dependent upon cultural factors, the color saturation is genetically predetermined. In most species, the flowers are white. In some, however, (notably *H. macrophylla*), they can be blue, red, or purple, with color saturation levels ranging from the palest of pinks, lavenders & powder blues, to deep, rich purples, bordeauxs, and royal blues. In these species, floral color change occurs due to the availability of aluminum ions, a variable which itself depends upon the soil pH. For *H. macrophylla* and *H. serrata* cultivars, the flower color can be determined by the relative acidity of the soil: an acidic soil (pH below 7), will have available aluminium ions and typically produce flowers that are blue to purple,^[13] whereas an alkaline soil (pH above 7) will tie up aluminium ions and result in pink or red flowers. This is caused by a color change of the flower pigments in the presence of aluminium ions which can be taken up into hyper accumulating plants. In neutral soil (pH 6 to 7), hydrangea may be purple or a mix of blue and pink on a single shrub.

Hydrangea flowers will be pink in alkaline soil, but change to blue in acidic soil. So, mix up some apple cider vinegar and water, and give all the acid-loving plants a treat. Or change colors of your hydrangeas on a whim from pink to blue. Hydrangeas are the only plants that can be manipulated to change color while growing. You can change a flower's color by altering its plant cells' pH levels. By changing the soil to be more acidic or alkaline, you can change the flower's

color. Hydrangeas are the only flowers that react to changes in soil conditions. In neutral soil (pH 6 to 7), hydrangea may be purple or a mix of blue and pink on a single shrub. Red or pink blooms result from neutral or basic soil (pH 7 and above), whereas blue blooms indicate acidic conditions (pH less than 7). The flowers of this plant are sensitive to soil pH and change colour to reflect changes in acidity. Pink Hydrangeas indicate soil that is alkaline to neutral. Blue flowers indicate soil that is acidic. In some species of Hydrangea, flower color ranging from blue to red, is influenced by soil pH. In soil with low pH, aluminum ions (Al^{3+}) are more available for uptake by plants, altering the flower pigments to reflect more blue. In less acidic soil, the aluminum is less available for uptake, resulting in the flower pigments reflecting more red. Myrtillin, a red pigment produced by the plant, is bound by aluminium to co-pigments which are blue. Without aluminium, Myrtillin alone reflects red.



Fig.1. Different colours of hydrangea flowers

Cultivation and uses

Hydrangeas are popular ornamental plants, grown for their large flowerheads, with *Hydrangea macrophylla* being by far the most widely grown. It has over 600 named cultivars, many selected to have only large sterile flowers in the flowerheads. *Hydrangea macrophylla*, also known as bigleaf hydrangea, can be broken up into two main categories; mophead hydrangea and lacecap hydrangea. Some are best pruned on an annual basis when the new leaf buds begin to appear. If not pruned regularly, the bush will become very 'leggy', growing upwards until the

weight of the stems is greater than their strength, at which point the stems will sag down to the ground and possibly break. Other species only flower on 'old wood'. Thus, new wood resulting from pruning will not produce flowers until the following season. Hydrangea root and rhizome are indicated for treatment of conditions of the urinary tract in the Physicians' Desk Reference for Herbal Medicine and may have diuretic properties. Hydrangeas are moderately toxic if eaten, with all parts of the plant containing cyanogenic glycosides. *Hydrangea paniculata* is reportedly sometimes smoked as an intoxicant, despite the danger of illness and/or death due to the cyanide. The flowers on a hydrangea shrub can change from blue to pink or from pink to blue from one season to the next depending on the acidity level of the soil. Adding organic materials such as coffee grounds, citrus peel or eggshells will increase acidity and turn hydrangea flowers blue, as described in an article on Gardenista. A popular pink hydrangea called Vanilla Strawberry has been named "Top Plant" by the American Nursery and Landscape Association. The hybrid "Runaway Bride Snow White", bred by Ushio Sakazaki from Japan, was named Plant of the Year at the 2018 RHS Chelsea Flower Show.

Used as aesthetic and medicinal purpose

In Japan, *ama-cha*, meaning sweet tea, is another herbal tea made from *Hydrangea serrata*, whose leaves contain a substance that develops a sweet taste (phyllodulcin). For the fullest taste, fresh leaves are crumpled, steamed, and dried, yielding dark brown tea leaves. Ama-cha is mainly used for *kan-butsu-e* (the Buddha bathing ceremony) on April 8 every year—the day thought to be Buddha's birthday in Japan. During the ceremony, ama-cha is poured over a statue of Buddha and served to people in attendance. A legend has it that on the day Buddha was born, nine dragons poured Amrita over him; ama-cha is substituted for Amrita in Japan. In Korean tea, *Hydrangea serrata* (hangul hanja) is used for an herbal tea called sugukcha or isulcha. The pink hydrangea has risen in popularity all over the world, especially in Asia. The given meaning of pink hydrangeas is popularly tied to the phrase, "You are

the beat of my heart," as described by the celebrated Asian florist Tan Jun Yong, where he was quoted saying, "The light delicate blush of the petals reminds me of a beating heart, while the size could only match the heart of the sender. *Hydrangea quercifolia* was declared the official state wildflower of Alabama in 1999. Hydrangeas were used by the Cherokee people. A mild diuretic and cathartic, it was considered a valuable remedy for removal of stone and gravel in the bladder.

The metal key of colour variation

Soil acidity actually is not the underlying chemical mechanism behind the color change of Hydrangea sepals. It ultimately depends on the availability of aluminum ions (Al^{3+}) within the soil. In acidic soil, Aluminum ions are mobile and reacts with the readily available ions so that it can be taken up into the hydrangea bloom to interact with the red pigment. But in neutral to basic soil, the aluminium ions combine with hydroxide ions (OH^-) to form immobile aluminum hydroxide, $Al(OH)_3$.

So, for the bluing of hydrangea blooms, one needs both aluminum ions and acidic soil. The best soil additive for bluing is one that contributes both, e.g., commercially available aluminum sulfate, $Al_2(SO_4)_3$. Oppositely, addition of lime (calcium hydroxide, $Ca(OH)_2$) changes the bloom-color from blue to red.



Fig.2. Hydrangea colour chart

Color change with pH

Hydrangea blooms possess blue sepals when the shrub grows in acidic soil, but develop red or pink sepals when grown in neutral to basic soils. This means that Hydrangea's bloom color acts as a natural pH indicator for the soil. In fact, a hydrangea can

have different bloom colors on the same bush if the roots of the plant sample soils of differing pH.

Fig. 3. Flower colour change with pH



Hydrangeas are ubiquitous— but they are not what they seem. For starters, the bloom of the hydrangea is not a true flower, but an inflorescence: Sepals, or modified leaves, make up most of the bloom and overshadow the small, almost unnoticeable fertile floral portions at the center.

The bloom colors are what really make the hydrangea stand out: They range from pink to blue, including all shades of color. Only yellow and orange remain absent.

How to Change Your Soil to Get Blue Hydrangeas

To get blue blossoms, your soil needs to be acidic, ideally from 5.0 to 5.2. This pH allows the hydrangeas to better absorb aluminum in the soil. Blueberries, raspberries and other common flower varieties do well in acidic soil. So, if you are looking to plant those in your garden, blue blossoms indicate your soil is ready. Adding aluminum sulfate to your soil will lower the pH and give your hydrangeas the aluminum needed to produce the blue hue. Lowering your soil's pH is not an overnight fix; it takes time. If you simply want the blue flowers, consider planting them in pots where you have much more control over the soil pH.

More Alkaline Soil Will Result in Pink Blossoms

Most plants prefer a soil pH of 6.0 to 7.3. Getting the pH to the top of this range will result in a slightly alkaline composition. This means any aluminum in the soil will be harder for the plant to absorb, and so the flowers will be pink. If your soil pH is between 5.2 and 6.0, you may end up with pink and

blue blossoms. Lilacs, garlic and asparagus all prefer more alkaline soil. Pink flowers are a good indicator the soil is ready for them. If your soil is not already alkaline, add lime to raise the pH. As with the blue flowers, if you'd rather not wait for the soil pH to adjust, consider putting them in pots rather than directly in the ground.

Conclusion

There is still much to learn about natural changes in the color in hydrangea blooms. By considering the coloring of Hydrangea, it is visible that metal ions as well as pH play a key role to create designer colors for flowers. Yet when it comes to hydrangea colors, there are always more chemical mysteries awaiting a solution.

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