Sulfur in Groundwater

Sulfur occurs naturally in soils, rocks and minerals. In the aquifer, groundwater comes in contact with these solid materials, dissolving them and releasing their constituents, including sulfur (S), into the water. In groundwater, under typical pH conditions, sulfur can occur as three separate ions: sulfate ($[SO_4]^{2-}$), bisulfide ($[HS]^{1-}$) and hydrogen sulfide (H_2S). None of these molecules are regulated by the federal Environmental Protection Agency (EPA), although a secondary standard of 250 mg/L (parts per million) has been established for sulfate. Secondary standards are suggested maximum levels for either a cosmetic or aesthetic reason. Above the 250 mg/L level, sulfate can impart a taste to the water and, depending on the individual, may have a laxative effect. More information is available on EPA's website (https://www.epa.gov/ccl/regulatory-determination-1-support-documents-sulfate). From an aesthetic point of view, however, the molecule H_2S is probably the most offensive, having the distinct and unpleasant odor of rotten eggs.

Sulfur molecules can be found in most groundwater. Whether it occurs as sulfate, bisulfide, or hydrogen sulfide depends on the amount of oxygen in the water and, to a lesser extent, upon its degree of acidity, i.e., its pH. Sulfur can occur in two forms: as S^{2-} and as S^{6+}. When levels of dissolved oxygen in groundwater are greater than 1–2 mg/L, sulfur occurs as S^{6+} and the sulfate molecule predominates. At lower or no dissolved oxygen levels, the sulfur occurs as S^{2-} and either HS^{1-} (at a pH greater than ~7) or H_2S (at a pH less than ~7) occurs. The pH at which the divide occurs may differ as a function of the total water chemistry.

Dissolved oxygen content is typically low in deep aquifers, or even in shallow aquifers, particularly if the aquifer contains organic matter. Decomposition of the organic matter depletes the oxygen in the water and the sulfur occurs as S^{2-}. Under these conditions, dissolved hydrogen sulfide is the common sulfur form and is often accompanied by dissolved iron (Fe) or manganese. When this water is pumped to the surface, the rotten egg odor is detected and the dissolved iron reacts with the oxygen in the atmosphere,

changes to Fe^{3+} (i.e., is oxidized) and forms rust-colored stains.

Many well owners notice the rotten egg smell only occasionally, or perhaps seasonally. This occurs as a result of the amount of recharge water arriving at the aquifer from the surface, or in the summer because the extent of drawdown of the water table results in a deeper portion of the aquifer being tapped. The actual cause and timing of the variation must be considered on a case-by-case basis. Importantly, the sudden occurrence of the rotten egg smell does not necessarily mean that your drinking water source has been affected by some pollution event. It probably represents natural variations in water chemistry (See Natural Variations in the Composition of Groundwater at https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/DRINKINGWATER/SOURCEWATER/Documents/gw/chem.pdf.)

Treatment of the water to remove the hydrogen sulfide odor can be accomplished as easily as letting the water set until the hydrogen sulfide, which occurs as a gas, dissipates into the atmosphere. If the smell persists, there are several treatment options, all of which oxidize the sulfur so that the hydrogen sulfide is transformed into sulfate. These options include introducing air or oxygen into the water as it comes from the pump or using an oxidizer such as chlorine. Importantly, if outside air is used, you should also disinfect the water to inactivate any microorganisms that might be introduced during the process. To reduce the chlorine taste and odor in your water, you might consider a carbon filter after the chlorine has had sufficient time to act.

For best results, contact a local water treatment business (search for “water treatment,” “water purifying,” or “water filtration”). They will have experience with local groundwater conditions and will be able to provide the best assistance.