



Turbidity of water

What is Turbidity?

In general terms, turbidity is a measurement of how cloudy a body of water is. Imagine a glass of drinking water – it's clear and translucent and has low turbidity. Mix in gravy granules or coffee and the water is no longer clear and the turbidity level has increased, indicating a high percentage of suspended particles in the water. However, just because a water sample has a low turbidity level does not necessarily mean it is safe to drink. It may still be contaminated.

Water almost always contains suspended solids, consisting of particles of varying sizes and properties, some of which are invisible to the human eye. Some of the larger particles are heavy enough to eventually settle to the bottom of a container if a sample is left standing (settleable solids). It is the particles which do not settle, termed colloidal solids, which cause water to look turbid. Particles which can be found in waterbodies causing water to become turbid include clay, silt, inorganic or organic matter, microscopic organisms (phytoplankton) and/or algae. A certain amount of turbidity in watercourses is normal. Many rivers naturally become quite turbid during floods, it doesn't necessarily mean there is a problem. There are no rivers in Wales that are permanently turbid.



On the left a glass of water with a high turbidity level. On the right a glass of water with a low turbidity level.

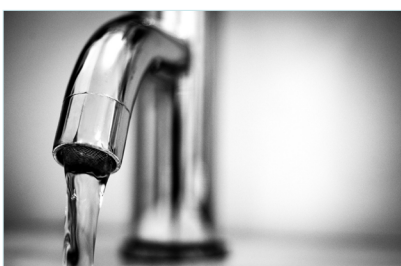
How is turbidity measured?

Turbidity is assessed by measuring the amount of light that is scattered by suspended particles when a light is shone through a water sample. The higher the intensity of scattered light, the higher the turbidity level of the water and the less transparent the water is. In lakes, turbidity levels are assessed using a Secchi disk, named after its inventor Angelo Secchi in 1865. A Secchi disk is a 20 cm diameter plastic disk with alternating black and white quadrants which is lowered into the water until it can no longer be seen from the surface. The point at which the disk disappears allows for a quick determination of turbidity. Alternatively, a turbidity tube, a small plastic tube with a small scale Secchi disk at its base is used or an electronic turbidity meter can be used. Measurements are best taken directly in the water that is being monitored.



Secchi disk

Turbidity results are reported in units called Nephelometric Turbidity Units (NTUs). As a rule, the higher the NTUs, the higher the concentration of suspended solids in the water is, the dirtier it looks and the higher the turbidity is. However clear water is not always healthy, and likewise turbid water does not necessarily indicate an issue.



The water industry has turbidity control parameters for drinking water, ensuring that what comes out of the tap is safe for human consumption. At a treatment works turbidity standards are set at two points in the water supply chain, at the treatment works and at the consumers' taps. According to the World Health Organization, the turbidity of drinking water should never exceed 5 NTU. In Wales, the standard for acceptable levels of turbidity in drinking water set by the Chief Inspector of Drinking Water is less than 1 NTU.



Causes of increased turbidity

Turbidity levels and the amount of sediment present in a body of water can be increased by both natural and human activities.

Cause - Deposition

Having a certain amount of turbidity in a watercourse is natural and necessary for the development of a healthy aquatic ecosystem. From weathered material that has been transported from the hills into the river through rainfall, runoff, melting snow or ice to finer material which has been eroded from the bed and banks of the river, water gathers soil and silt particles ensuring there is always some movement of sediment in a waterbody such as a river. Sediment particles are deposited when water flows slowly, or the load becomes too heavy to be carried further. The particles settle to the bottom of a watercourse.



Rainwater carrying weathered material

The deposition of sediment is important for the development of aquatic ecosystems helping to replenish nutrients and create spawning areas for fish. However, if deposition rates become too high water can become temporarily turbid. Large amounts of suspended materials can clog the gills of fish and kill them. High turbidity can also make it difficult for fish to see, breed and function under water.

Typically, turbidity levels increase from a river's uplands to its lowlands. If levels of suspended solids in water are high when they come out of suspension, they will normally settle during the lower course of a river as it makes its journey towards the sea. In a natural river system these solids would settle on a river's floodplain but sometimes due to the necessity of having to build flood defences to reduce the risk of flooding there isn't always room for floodwater to settle on natural floodplains. This can lead to the clogging of river channels as suspended solids settle on the bottom of the river bed smothering fish eggs and aquatic invertebrates.

Increased sediment in rivers, lakes and streams can affect water quality and the availability of drinking water sources. For example, increased sedimentation can affect the storage capacity of reservoirs and increase the need for water treatment by water utility companies.

Cause - Increased flow and water velocity



A turbid river in high flow

Turbidity levels vary over time. High flows are typically associated with increased inputs of sediment. Most of the sediment in rivers and streams comes from catchment and stream bank erosion. During high rainfall, water may flow over land, directly into a waterbody, as run off or through drains as stormwater. This water collects silt and soil particles as it flows, transporting the particles into the nearest watercourse. This increased sediment loading from run off, coupled with higher and faster water velocity means that the effects of erosion processes such as abrasion*¹ and hydraulic action*² are

increased. The geology of the land can make an area more susceptible to the effects of erosion as some rock and soil types such as clay and peat are more likely to erode than others.

Accelerated erosion processes caused by increased flow and water velocity can increase the levels of suspended sediments in watercourses and in turn increase turbidity levels. Increased levels of erosion can also change the normal distribution of sediment, negatively impacting river ecosystem health.

***1: Abrasion** - Transported material such as pebbles and stones wear away the river's bed and banks - a bit like sandpaper being applied to the river's banks.

***2: Hydraulic action** - (the force of water as it smashes horizontally against river banks and vertically onto the river bed, forcing air into crevices and cracks, causing the rock to weaken over time.



Cause - Mixing of freshwater and saltwater

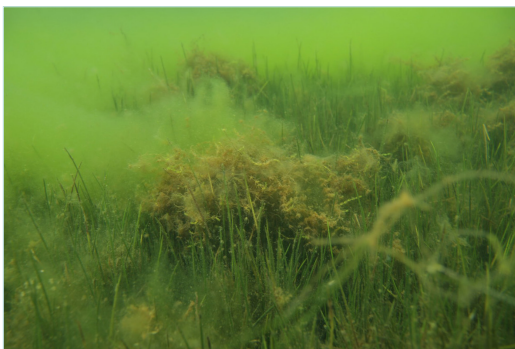
Estuaries are complex systems, all of which behave in slightly different ways, largely dependent on the tidal regime and freshwater flow. In Welsh estuaries, which have moderate to high tidal ranges, partial mixing can occur as freshwater from a river enters an estuary and mixes with saltwater from the sea. The less dense freshwater from the river flows out over the denser saltwater which enters the estuary with the tide beneath the outflowing river water, pushing its way upstream along the bottom of the estuary channel. The freshwater and saltwater can flow smoothly with little mixing however when the difference in velocity between the salt and freshwater reaches a certain level, vigorous mixing can occur, mixing the water types together, resuspending sediments and producing brackish, turbid water in the estuary.



Aerial image of turbid freshwater water mixing with saltwater at a river's estuary.

Cause - Algae

Algae are aquatic photosynthetic organisms that can live in saline and freshwater and form the foundation of food webs. Algae are found growing where there is an increased availability of one or more growth factors:



Underwater image of an algal bloom

- sunlight
- high volumes of carbon dioxide

An accumulation of nutrients often caused by pollution, such as wastewater, sewage and agricultural runoff e.g. if livestock manure/slurry enters a watercourse slowly over a period of time it can cause eutrophication (the process by which a watercourse becomes enriched in dissolved nutrients such as nitrogen and phosphates).

As algae decay in water, the decomposition process allows small organic particles to break away and exist in water as suspended solids, increasing turbidity levels.

Cause – Human actions

Sediment entering waterways is a natural process, but human land use can result in excessive quantities entering waterways. Human activities that disturb land such as construction, forestry, mining and agriculture can all lead to extensive soil disturbance, erosion and sediment runoff into rivers and streams.

Pollution and debris suspended in water runoff from roads, pavements or storm drains in urban areas can increase turbidity as they enter watercourses during periods of heavy rain. Agricultural pollution such as slurry and milk can also cause very high levels of turbidity in watercourses. Other sources of sediment include sewage effluent discharges, septic tank discharges and industrial discharges.

Discharge and waste water from industries, quarrying, mining and abandoned mines can contain dissolved metals, chemicals and pathogens which can again increase turbidity in watercourses and prove to be toxic.



If spread slurry makes it way to a watercourse it can increase turbidity levels.



What impact does turbidity have on waterbodies?



A decrease in dissolved oxygen levels in water can have negative consequences for aquatic life.

High turbidity can increase water temperature as the suspended particles absorb heat from sunlight more efficiently than water. The generated heat is transferred from the suspended particles to water molecules, increasing the temperature of the surrounding water.

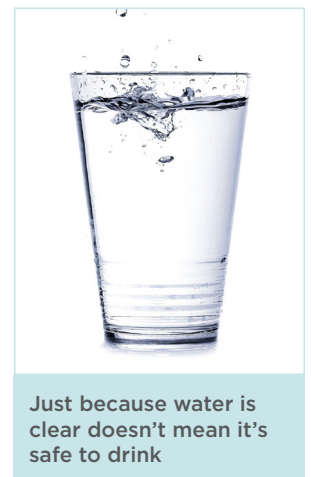
Raised water temperature can lead to a decrease in dissolved oxygen levels in the water which can have negative consequences for aquatic life.

It's also possible for sunlight to heat the turbid surface of the water whilst restricting light penetration to the bottom of the waterbody, reducing the rate of photosynthesis. High turbidity levels in water bodies such as lakes, rivers and reservoirs reduce the amount of available light that reaches the lower depths, restricting the depths at which aquatic plants can grow.

What impact does turbidity have on human health?

Many things can affect the turbidity of drinking water including industrial or agricultural pollution incidents, human and animal waste, insufficient treatment or natural events.

Turbid or cloudy drinking water does not look inviting but just because water is clear doesn't mean it is safe to drink. It may contain contaminants that are invisible to the naked eye. Turbid water can provide food and shelter for viruses and pathogenic bacteria which attach themselves to the suspended solids in the water. The higher the level of turbidity in drinking water the greater the chance that it is harbouring viruses and pathogenic bacteria resulting in health issues such as nausea, headaches and gastrointestinal illnesses if drunk. Water companies carefully monitor water quality levels and their water treatment processes can effectively remove turbidity from drinking water and ensure that the water does not contain contaminants, reducing the risk to human health.



Just because water is clear doesn't mean it's safe to drink

Follow up activity

Have a go at gauging the turbidity level of a local pond or watercourse. Try out our 'Activity Plan - Measuring the turbidity of water' and make a homemade turbidity meter by printing out our 'Resource card - Measuring the turbidity of water'.

Additional information

Information Note - Dissolved Oxygen in Water

Information Note - Managing groups in and around/near water

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