

# GEOSMIN

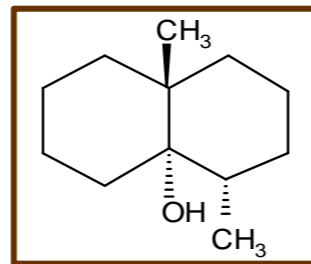


Homi Bhabha Centre for Science Education  
HBCSE, TIFR  
<https://chem.hbcse.tifr.res.in/>

Molar Mass- 182.30 g mol<sup>-1</sup>  
Boiling Point - 270°C



*Actinomyces israelii*



Geosmin

Geosmin is a metabolite secreted by microbes such as the blue green algae, soil dwelling actinomycetes bacteria etc. The earthy smell released from soil after first rain is predominantly due to Geosmin. Only the (-) enantiomer of Geosmin is formed in this natural process. The pure compound is a colourless liquid belonging to the terpenoid family (which was earlier largely associated with plants).

In spite of its high boiling point and low vapour pressure (10<sup>-6</sup> atm), the human nose can detect it in concentrations as low as 5 parts per trillion. Its odour is considered pleasant by many reflecting the freshness of nature but considered foul when found in drinking water.



In olden days our ancestors use the odour of geosmin to find source of water bodies.

## Do you know??

Camels can detect the smell of geosmin from wet ground miles away and they track this smell to find the oasis.



## Discovery of Geosmin

Of the large number of organic compounds present in natural waters, the compounds that impart earthy/musty taste and odour to drinking water have always been most difficult to remove.

In the late 19<sup>th</sup> century, it was identified that actinomycetes were responsible for odour-producing compounds in water.



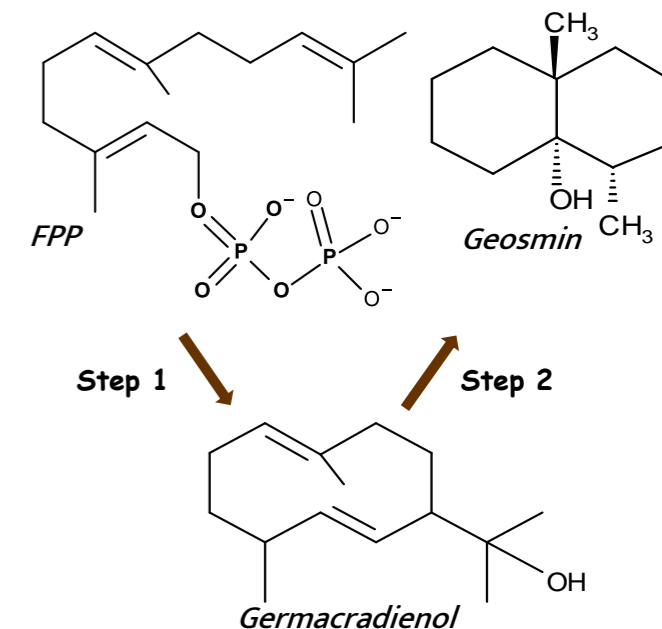
In 1965, two American Scientists– *Nancy N Gerber* and *Hubert A. Lechevalier* were the first to show a single compound isolated from several species of actinomycetes was responsible for earthy taste and odour and named the compound '*Geosmin*' which translates to '*earthy smell*' in Greek. In 1969, *Medsker* along with *his co-workers* identified and isolated 2-methylisoborneol (MIB) which is also responsible for earthy odour in water.



## Recent Research...



In 2006, biosynthetic pathways of geosmin were discovered, and were found to involve multiple cyclization steps starting from diphosphates of acyclic terpenes. In one such process in *Streptomyces coelicolor* species (soil organism), farnesyl diphosphate (FPP) gets converted into (-) geosmin in a two step enzymatic process.



Natural (-) geosmin has 11 times lower threshold odour than its (+) enantiomer and therefore has a stronger smell.

## Does it occur anywhere apart from water and soil?

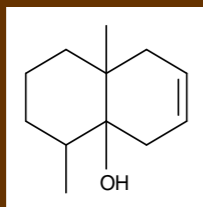
1) The earthy taste and smell of both table beet and sugar beet owe to geosmin.



2) The musty smell of geosmin is also found in wines. Geosmin is formed in rotten grapes by the action of *Penicillium* fungi and a few other bacteria.

### Did you know?

Some cactus varieties growing in extremely hot conditions make 'dehydrogeosmin' which has ten times more odour than geosmin. This attracts insects which in turn serve as pollinators.



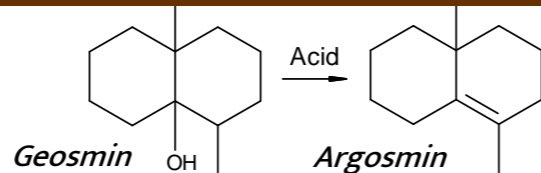
Dehydrogeosmin

Geosmin released in the water (by microorganisms) is absorbed by bottom-feeding freshwater fish like catfish, trout, carp, etc. giving their flesh an earthy taste.



### Do you know?

Why are muddy tasting freshwater fish— eaten with lemon juice and vinegar? Geosmin reacts with acids to form an odourless compound **Argosmin**.



### Nature fact

Geosmin deters plant predators and attract organisms that disperse spores. Geosmin also repels fruit flies, so they are less likely to eat materials on which actinomycetes are growing.

### The Perfume

Legendary perfumers of ancient Kannauj, in Uttar Pradesh, could create a unique scent in the past that would capture the fragrance of the earth when first touched by monsoon rains known as '*Mitti ka attar*' (*Gil attar*).



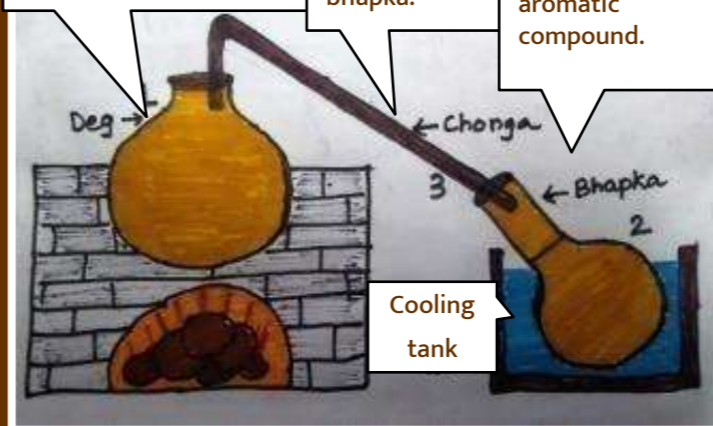
It is extracted from parched clays and distilled using ancient form of hydro-distillation process known as **Deg and Bhapka system**. The procedure starts with baking the clay extracted from top soil starting after the monsoon. Kannauj produces many perfumes from thousands of years and is known as '*the perfume capital of India*.'

#### Deg (still):

Large copper vessel in which water and clay, extracted from the top soil after monsoon, are placed. Dung cakes/wood is burnt underneath the deg.

**Chonga** (condenser): Hallow bamboo pipe that connects the deg and bhapka.

**Bhapka** (receiver): Copper vessel with a large belly and a narrow neck. It is cooled and filled with sandalwood oil to dissolve the aromatic compound.



The fragrance thus collected is stored in leather bottles made of camel skin. Leather is used because any water contained in the distillate can pass from the porous membrane of the leather while holding in the fragrance and oil. The bottles are for aging the perfume.

Also if there is any unrefined material left in the attar, it settles at the bottom and can be easily removed by filtration.



### References and further reading

- Lindholm-Lehto, P. C., & Vielma, J. (2018). Controlling of geosmin and 2-methylisoborneol induced off-flavours in recirculating aquaculture system farmed fish—A review. *Aquaculture Research*, 50(1), 9–28. <https://doi.org/10.1111/are.13881>
- The whitelotusaromatic site (1996, February), Retrieved May 5, 2020, from [https://www.whitelotusaromatics.com/index.php/newsletters/visit\\_to\\_kannauj\\_4\\_production\\_of\\_traditional\\_attars](https://www.whitelotusaromatics.com/index.php/newsletters/visit_to_kannauj_4_production_of_traditional_attars)

### Image sources

See the supplementary document.



### Now, Can you find?

- What is petrichor? What are the other contributors for the smell of rain?
- Does roots and tubers other than beetroot have the smell of geosmin?
- What is the IUPAC name of geosmin?

For more questions, refer Indian National Chemistry Olympiad questions (2018 paper): Problem 2- <https://olympiads.hbcse.tifr.res.in/>