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Article Title *(Arial, Bold, 20 point, 10 word limit)*	**Mountaintop mining in West Virginia impacts the Mud River**

Article Preview/"Teaser" *(10-15 words, Arial, 16 point)*

What is mountaintop mining? What impacts does it have on the Mud River?

Full Article Text *(1000-1500 words, Use Arial and 10 pt. font size)*

Coal is one of the many sources of energy that exist on Earth. Coal is discovered through mountaintop mining. Mountaintop mining is the process by which several layers of sedimentary rock are removed from mountains in order to make the coal beds below more accessible (Vengosh *et al.,* 2013). After the coal rocks are separated from the non-coal rocks that were mined in the process, the non-coal mined rocks, or overburden, are pushed into nearby streams (Vengosh *et al.,* 2013). This disposal process creates valley fills, which bury the source of the streams (Vengosh *et al.,* 2013).

Mountaintop mining is the main way of discovering coal in the Central Appalachian area (Lindberg *et al.,* 2011). West Virginia is one of the states that is highly involved in mountaintop mining within this specific area. Located in West Virginia is the Mud River. The Mud River is a tributary of the Guyandotte River that runs through Lincoln and Boone Counties (Arnold *et al.,* 2014). The Mud River supplies drinking water to some residents of Boone County. Therefore, it is important to keep this water clean and safe to use.

Lincoln County, West Virginia, is home to several mountaintop coal mines, including Hobet-21. The Hobet-21 coal mine is one of the largest mountaintop mines stationed in West Virginia (Arnold *et al.,* 2014). Hobet-21 has expanded its coal exploration between 1987 and 2002 (NASA, 2007). Advancements in technology have contributed to this expansion. For example, Hobet-21 has a piece of mountaintop mining equipment known as “Big John,” which can collect approximately one hundred tons of earth in only a single attempt (Mitchell, 2006).

Mountaintop mining, though efficient in collecting large amounts of coal, does come with consequences. Downstream of these sites, water quality and aqueous organisms are being negatively affected (NASA, 2007). One negative effect of mountaintop mining is increased selenium contents (Arnold *et al.,* 2014). Selenium is found in coal rocks and can escape into the environment through natural processes (Arnold *et al.,* 2014). The selenium contents are typically found directly downstream of valley fills and mountaintop mining. Because of this, scientists believe that there is a direct correlation between increased mountaintop mining upstream and increased selenium contents found downstream (Vengosh *et al.,* 2013).

To test this theory, Duke University collected water samples from May 2010 to December 2010 from 23 locations along the Mud River within Lincoln and Boone Counties (Vengosh *et al.,* 2013). The samples were filtered to separate the selenium from the water. Compared to previous studies, the water samples collected contained higher levels of selenium in the Mud River within Boone County. The level of selenium concentrations in freshwater deemed safe by the Environmental Protection Agency (EPA) is 5.0 µg/L (Arnold *et al.,* 2014). The concentrations of selenium in the test locations downstream of mountaintop mines exceeded the EPA’s safety level (Vesper *et al.,* 2008). However, the concentration of selenium in the test locations upstream (near the mountaintop mines) did not exceed the set limit (Lindberg *et al., 2*011).

Studies were conducted on fish within the area as well. Low concentrations of selenium are important in diets, but an excessive amount can have negative effects on organisms that are exposed to these high concentrations (Purmure *et al.,* 2009) The goal of the study was to determine whether or not increased selenium contents in the Mud River had any impact on the tissues of fish. To test this, fish were collected using an electro-shocker from March 2011 to July 2013 in similar locations to that of the water samples previously collected (Arnold *et al.,* 2014).

Fish species collected included both green sunfish (*Lepomis cyanellus*) and bluegill sunfish (*Lepomis macrochirus*). After being electroshocked, the tissues of the green sunfish were dissected, and those showing deformities were freeze dried after being crushed into powder (Arnold *et al.,* 2014). The deformed green sunfish that were collected from the mining areas upstream of the Mud River in April 2011 had selenium concentration levels between 6.6 and 7.8 mg/kg (Arnold *et al.,* 2014). In contrast, the deformed green sunfish collected downstream in the mining-impacted areas of the Mud River in May 2012 contained higher selenium concentration levels of approximately 10.3 mg/kg (Arnold *et al.,* 2014).

Also, the West Virginia Department of Environmental Protection (WVDEP) studied the larval deformity rates of the collected bluegill sunfish (Arnold *et al.,* 2014). The typical larval deformity rate of bluegill sunfish is approximately 0-1.3%, which is similar to the results of the fish collected from the Lincoln County area; however, this rate was increased to a range of approximately 0-48% for the bluegill sunfish collected in the Boone County areas downstream of mountaintop mines (Arnold *et al.,* 2014).

The studies shown on both fish tissues and the water of the Mud River revealed two things. Firstly, the results showed that both the fish and the water in the Mud River within Boone County have increased in selenium content levels over time. Secondly, the results showed that the selenium content levels did not increase in Lincoln County where the mountaintop mines are located; instead, they increased specifically downstream of the mountaintop mines. During this time period, the Hobet-21 mountaintop mine was increasing its coal exploration range. As Hobet-21 increased in size, selenium levels increased directly downstream of the mine. Therefore, Hobet-21 may be the main contributor to the increase selenium contents downstream.

The deformities found in the fish of the mining-impacted areas of the Mud River is alarming because, as mentioned previously, the water from the Mud River provides a water supply for some one hundred residents in the same area. Most of what scientists know about the effects of too much selenium intake on humans (*Homo sapiens*) is based off the effects it has on animals (Rayman *et al.,* 2008). Fish are normally an indicator of what may be happening to humans.

Connelly Branch of the Mud River is one of the largest valley fills in the United States and is one of the valley fills impacting the Mud River within Boone County (Arnold *et al.,* 2014)). In order to prevent any further damage to the Mud River environment or any possible health effects on humans within Boone County, we must clean up the branch that is causing the harm – Connelly Branch. Georges Branch of the Big Coal River is the location of six valley fills where strategies to combat increased metal contents, such as selenium, have been tested (Cook *et al.,* 2008). In order to prevent further damage from the valley fills in Georges Branch, five of the six existing valley fills in the area were filled with alkaline sandstone in order to neutralize the acids and metals present from mountaintop mines (Cook *et al.,* 2008). The results showed decreased acidity and metals in the five selected valley fills, and water qualities still continue to improve (Cook *et al.,* 2008). Filling the Connelly Branch valley filly with alkaline sandstone, as was done with the Georges Branch valley fills, could similarly decrease concentrations of metals, specifically selenium, left over from mountaintop mining in Lincoln County.

Search words *(minimum of three, maximum of 6, use Arial and 10 pt. font size)*

Boone County, Lincoln County, Hobet-21, Mountaintop Mining, Mud River, Selenium

Figure Legends for accompanying illustrations, tables, graphs, and photographs *(Use Arial and 10 pt. font size)*

Figure 1. Hobet mine, 1984-2009. The Hobet-21 coal mine is a mountaintop mine located in Lincoln County, West Virginia. These side by side images show the size of the mine in 1984 and again in 2009. The area taken up by the mine in 2009 is much greater than the area that was taken up twenty five years earlier. This photo is in the public domain and was provided by National Geographic.

Figure 2. Effects of mountaintop mining. This flow chart shows the connection between mountaintop mining and valley fills and the connection between valley fills and increased selenium downstream. Mountaintop mining removes coal and non-coal rocks. Then, the non-coal rocks are placed in adjacent stream and form valley fills. The valley fills then cut off the headwater streams and lead to increased selenium contents downstream of the locations of the mountaintop mines.

Figure 3. Areal extent of mountaintop mines and selenium content downstream. This line graph shows the results of studies conducted by Duke University along the Mud River. The relationship between the areal extent of mountaintop mines and the concentration levels of selenium downstream of those mines is a direct relationship. As mountaintop mines increase in size,

concentration levels of selenium downstream increase. This graph was modified was from Lindberg, T.T., et al. (2011).

Figure 4. Selenium and fish. This photo shows the deformities of a green sunfish (*Lepomis cyanellus*) caused by toxic levels of selenium in the Mud River test sites. This photo is in the public domain and was provided by Arnold, M.C., et al. (2001).

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Glossary (Use Arial and 10 pt. font size)

Acidity – the level of acid (a chemical substance that neutralizes alkalis) in a substance.
Alkaline – having the properties of an alkali (a chemical compound that neutralizes acids).
Direct Correlation – a relationship in which large values of one variable are associated with large values of the other and small with small.
Electroshock - the application of electric current to cause a disturbance.
Hobet-21 – a mountaintop mine located in Lincoln County, West Virginia; it is one of the largest coal mines in West Virginia.
Mountaintop Mining – a coal mining process which involves removing the top of a mountain with explosives.
Overburden – material overlying a deposit of useful geological materials or bedrock.
Sandstone – sedimentary rock consisting of sand or quartz grains cemented together.
Selenium – the chemical element of the atomic number 34.
Tributary – a stream or river that flows into a main stem river or lake.
Valley Fill – the waste produced by mountaintop removal mining that is placed in adjacent streams.

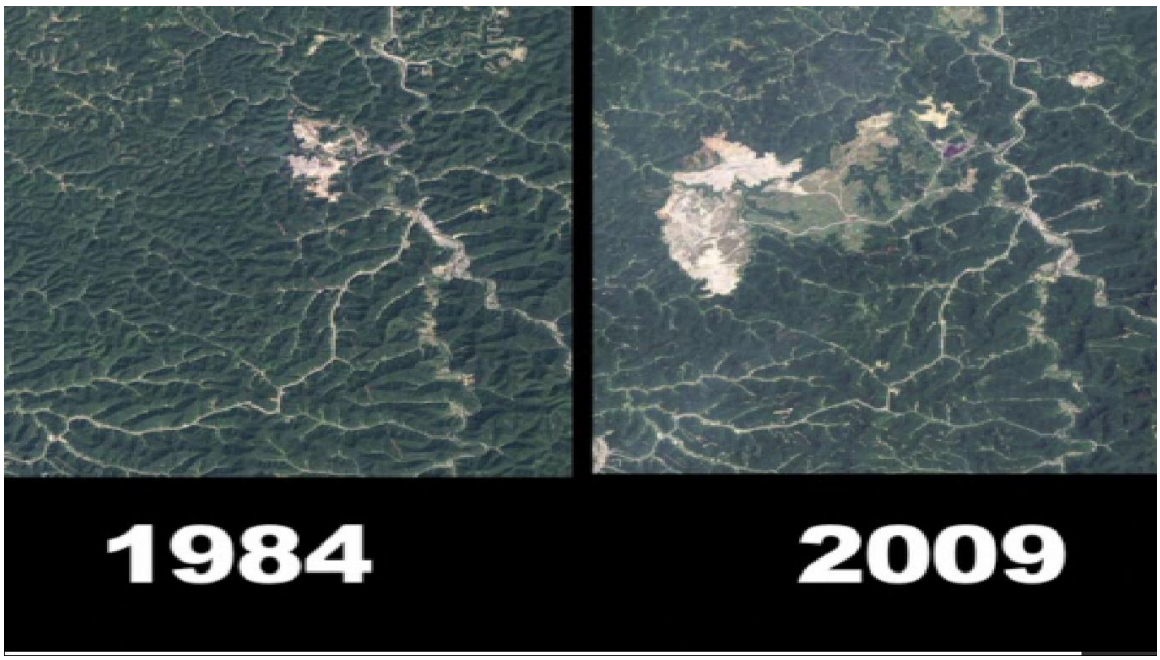

Figure 1.

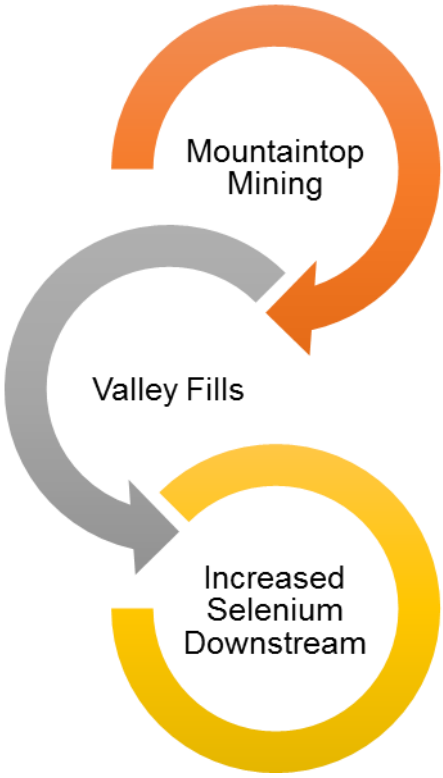
Mountaintop Mining
Valley Fills
Increased Selenium Downstream

Figure 2.

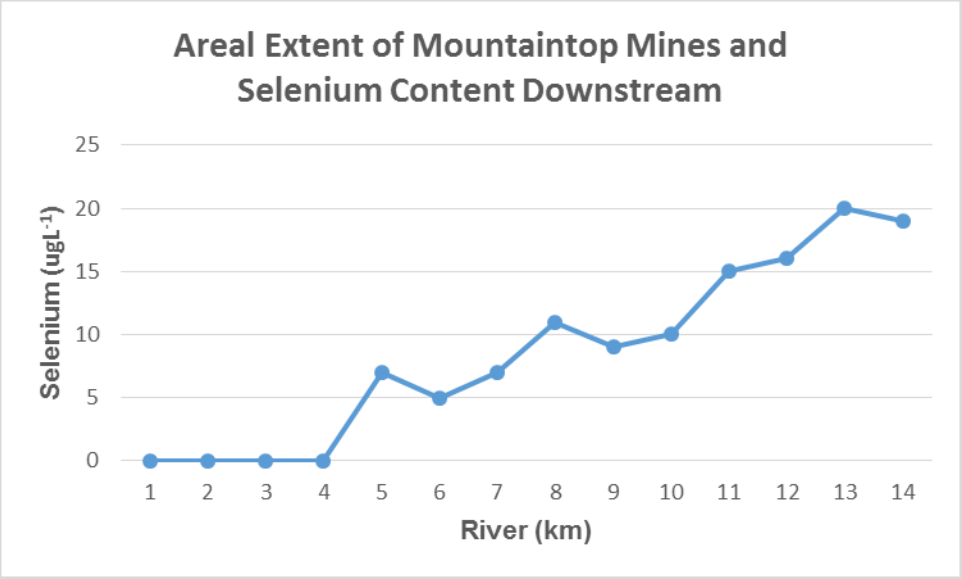
Areal Extent of Mountaintop Mines and Selenium Content Downstream
Selenium (ugL-1)
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
River (km)

Figure 3.

Figure 4.