Effects of Different Types of Water on the Degradation Rate of Human DNA in Bone and Tissue

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Abstract

Human remains have been subjected to aqueous environments for periods of time are often used for DNA analysis of the tissue and bone for forensic applications. This paper has provided a problem of investigating the past due to the investigation and loss of DNA in the aqueous environmental conditions. The purpose of this research was to determine the quantity of viable DNA that can be obtained by removing DNA from human bone and tissue over a 72-hour period of time and whether or not a DNA profile can be made. Also, this research studied how different types of water environments such as saltwater, swamp water, and freshwater affect the amount of DNA degradation and the amount of DNA lost over the study period. In this study, human bone and tissue samples were placed in three aqueous environments (saltwater, swamp water, and freshwater) and allowed to incubate for 72 hours. These samples were then taken out and their DNA was extracted, quantified, amplified, and analyzed. The degradation and loss of DNA was studied for each sample and bone-tissue in comparison to a control sample that was not placed in water. It was found that there was a significant DNA degradation and loss in both tissue and bone samples that were immersed in water for 72 hours. The bone samples showed on average a ~10,000-fold reduction of detectable DNA. The bone sample that was immersed in saltwater showed a significant degradation and loss that was too small to detect with DNA at all. As for the tissue sample, there was an ~1.5 fold DNA loss for the control sample (dry sample) there was little to no DNA loss. (54.1 ng of DNA detected). The tissue samples showed much less detectable DNA than the control sample. (1.75 ng (freshwater), 0.97 ng (saltwater), and 1.96 ng (swamp water). These findings were consistent with the data collected in the previous study and support the theory that there is considerable DNA loss and DNA degradation after 24 hours of exposure.

Introduction

In areas along the shore or near larger bodies of water it is common for forensic investigators to find human remains that have been submerged. When remains are submerged in water, investigations rely heavily on DNA to help identify the individual. In situations such as natural disasters involving water or large accidents, such as a plane crash or a boat sinking, it is vital that investigators check for the remains of the victims to be identified. On March 8th, 2014 Malaysia Airlines Flight 370 went missing. It has since been theorized that the plane had crashed somewhere in the ocean and the remains of the plane and the victims have yet to be found. When the wreckage is discovered, especially considering the impact of the crash, the evidence will be highly decomposed and brittle. It will be very difficult to identify the remains of the victims by pure visual investigation. Investigators will rely on different methods of identification such as DNA analysis to try to identify the remains. Other incidents with mass casualties, such as the tsunami in Indonesia on December 26th, 2004 and Hurricane Katrina in August of 2005, the tsunami left thousands of victims. DNA identification of victims was utilized. Many of these victims had been exposed to water environments and extended period of time. The exposure to long periods of immersion made DNA analysis difficult. For remains that have been submerged in bodies of water existing DNA degradation has occurred. By determining the effect of different types of water on quickly DNA from bone and tissue samples, DNA degradation, it will aid in investigating in identifying remains that come out of aqueous environments. The soft tissue begins to detach from the bone and is consumed by organisms living in the environment, taken away by currents, or is decompacted. Since there is such a low chance of there being viable soft tissue remains, investigators rely largely on DNA analysis from bone.

DNA degradation results from strand breakage, chemical modifications, and microbial attack. These degenerative processes reduce the yield of high molecular weight DNA molecules and increase the chance of subsequent DNA isolation [2]. Of the many factors that lead to DNA degradation, one of the biggest factors in aquatic environments is damage due to hydrolysis. DNA has a high affinity to water and even after death DNA in dead tissues will continue to attract water molecules. When degradation occurs, DNA is immediately exposed to large amounts of water for long periods of time, there is a high chance of damage due to hydrolysis. Hydrolysis does not only happen in soft tissues but it also can occur in skeletal material as well. Water can enter bone through a process called bone dissolution. As this occurs the pores of the skeletal material become larger and allows for hydrolysis, leading to a greater loss of bone material. The greater the dissolution of the inorganic component of the bone, the greater the chance of DNA loss as the DNA molecules dissociate from the protection of the hydroxyapatite [3]. Due to hydrolysis that occurs in bone and soft tissue DNA can be degraded and unable to be used for further investigation and analysis.

Experimental Setup

In this study, human bone and tissue samples were placed in three aqueous environments (saltwater, swamp water, and freshwater) and allowed to incubate for 72 hours. These samples were then taken out and their DNA was extracted, quantified, amplified, and analyzed. The degradation and loss of DNA was measured for each sample and bone-tissue in comparison to a control sample that was not placed in water. It was found that there was a significant DNA degradation and loss in both tissue and bone samples that were immersed in water for 72 hours. The bone samples showed on average a ~10,000-fold reduction of detectable DNA. The bone sample that was immersed in saltwater showed a significant degradation and loss that was too small to detect with DNA at all. As for the tissue sample, there was an ~1.5 fold DNA loss. The control sample (dry sample) there was little to no DNA loss. (54.1 ng of DNA detected). The tissue samples showed much less detectable DNA than the control sample. (1.75 ng (freshwater), 0.97 ng (saltwater), and 1.96 ng (swamp water). These findings were consistent with the data collected in the previous study and support the theory that there is considerable DNA loss and DNA degradation after 24 hours of exposure.

Discussion

Significant DNA loss was observed in the bone samples treated in all three water environments. The starting quantity of DNA in the bone (at time zero) was ~180.7 ng/μL. ~510 ng of DNA was detected for bone samples that were incubated in freshwater for 72 hours. This was a significant loss of DNA (~10,000 fold). ~4,030 ng of DNA was detected for bone samples that were incubated in saltwater for 72 hours (~10,000 fold). No detectable DNA was found for bone samples incubated in swamp water. The control bone sample incubated dry exhibited some DNA loss, but it was not as significant as the values of the bone samples that were placed in water; ~1.12 ng/μL of DNA (16 fold).

The tissue from the rib samples closely resembled the findings of the bone samples. The control tissue sample (dry) exhibited ~341 ng/μL of DNA. ~73 ng/μL of DNA was detected for tissue samples that were incubated in saltwater for 72 hours (~10,000 fold). ~504 ng/μL of DNA was detected for tissue samples that were incubated in saltwater for 72 hours (~10,000 fold). It was found that there were large amounts of DNA loss in both bone and tissue samples that were incubated in all three water environments for 72 hours. The bone samples showed much more extensive DNA loss than that of the tissue samples. In this bone samples begin to swell, resulting in a considerably larger DNA loss. The saltwater environment showed the most amount of DNA loss out of all three. This was consistent in both the bone and the tissue samples. From these results it is conclusive that there is a dramatic loss of DNA in human remains that have been immersed for 72 hours.

Conclusions

The 72-hour time period is very important in the timeline of DNA loss of human tissue and bone in aqueous environments. In the research previously done by Steven Armstrong [1], it was found that there was a critical loss of DNA in the bone between the time periods of 24 and 36 hours. The results of the 72-hour experiment were consistent with this previous data. It was found that there was not as extensive DNA degradation but more DNA loss, especially in the saltwater. The control to the bone samples it is indicative that there is much more substantial DNA loss and degradation occurs in the aqueous environment, proving that the ‘types of water do in fact have an affect on the human DNA.

References


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