MONITORING POLLUTION ON MURANO:

AN ANALYSIS OF THE ARTISTIC GLASS INDUSTRY OF MURANO, ITALY

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The project team, consisting of Joshua Black, Brian Cavanna, and Nicholas Cottreau, cohesively worked together to compose this project. While we worked with each other on each section of the report, certain sections were the responsibility of an individual team member. However, we feel that through our work and cooperation each member of the team contributed to this project equally.

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ABSTRACT

This project, sponsored by the *Comune di Venezia*, analyzes the problem of pollution associated with the artistic glass industry on the island of Murano in Venice, Italy. We obtained information to create a computer-based pollution monitoring system, which allows users to visualize and track the pollution on Murano. This system will be used by the *Comune di Venezia* to help glass manufacturers come into compliance with Italian environmental regulations on air, noise, and liquid pollutants by December 31, 2002.

EXECUTIVE SUMMARY

The island of Murano lies 1200 meters north of Venice, Italy. The island shares many of the same characteristics as Venice. Murano is made up of seven islands separated by a canal system. The canals provide a primary means of transportation as well as a sewage system into which waste is discharged. Murano is home to approximately 5700 people, most of whom are employed in some manner by the thriving artistic glass manufacturing industry. Murano has been a glass manufacturing center since the craft was moved to the island from Venice in the late thirteenth century. Glassmaking traditions and practices have been passed down through the family lineage. Today the industry faces new challenges. In trying to maintain the traditions of the trade, glass manufacturers struggle to meet environmental regulations. Failure to comply with the regulations may result in the possible closure of centuries old companies.

Our project sponsor, the *Settore Sicurezza del Territorio, Comune di Venezia* (Department of Territorial Safety for the City of Venice), has worked to pass special legislation, called the *Accordo sul Vetro* (glass accord), to extend the deadline for compliance with the environmental regulations until the end of 2002.

The goal of our project was to create a tool to assist the *Settore Sicurezza del Territorio* in monitoring the pollution created by the glass manufacturing companies of Murano. Our pollution monitoring system links together information concerning various sources of pollution created by the glass manufacturers. The system includes data for sediment in the canals, sewer pipes, septic tanks, noise levels, and air emissions, and is adaptable to input future pollutants and data. The 70 companies, out of a total of 155, that signed onto the *Accordo sul Vetro* are permitted to continue with their operations provided they take steps to meet the regulations.

The sediment that exists in the canals is a compilation of the liquid waste that has been piling up since the last time the canals were dredged, so it is difficult to attribute the pollution to a specific source. Currently, this is the only information that acts as an indicator of water pollution. Moreover, we used the blueprints of several glass manufacturing plants to locate their wastewater discharge points. In the future, this information can be used to test effluent streams for water quality. Upon locating the outlet, it is possible to test the exact location where the liquid waste enters into the canal system. Frequent testing of the water in these locations would provide an image of the actual levels of pollutants discharged by individual companies. In order to comply with the environmental regulations placed upon them, it is suggested that glass manufacturing companies install septic tanks to filter out their liquid waste before it enters into the canal system.

Many residents of Murano have complained about the levels of noise produced by the glass manufacturing companies. The levels of noise can be attributed to the many different operations and machines used by the manufacturers. During the night, most of the furnaces are in full operation preparing glass for the upcoming day while the residents are trying to sleep. Currently, twenty three locations throughout Murano are being monitored for noise levels in public areas. These locations were chosen based upon their proximity to glass manufacturing companies, distance from other monitoring stations, and the willingness of the building's owner to cooperate. The data retrieved from these locations can be used to determine the regions where the highest levels of noise are produced. This data will be used to determine whether to perform additional extensive testing of the noise pollution caused by the individual companies that operate within the monitored regions. Monitoring several additional sites would provide a more detailed picture of the noise pollution that exists on Murano.

Glass is created from a mixture of solid ingredients that are melted in furnaces at temperatures in excess of 1400 degrees Celsius. This process results in the emission of many chemicals into the atmosphere. In order to measure the levels of emissions released, the effluent stream must be tested. Chimneys provide a means to measure the emission levels because they concentrate the effluent stream into one channel. Although the use of a chimney is mandated by the accord, many of the glass manufacturing companies do not utilize chimneys yet. We used the blueprints of sixteen companies that have been authorized to install chimneys to determine the location of their chimneys. The levels of authorized emissions into the atmosphere were recorded for each chimney. Frequent and extensive testing of the chimneys at each of the companies would provide an image of the actual levels of pollutants released into the atmosphere. The use of a chimney allows the manufacturers to meet the environmental regulations being placed upon them. Currently, several pollution abatement techniques can be utilized with the installation of a chimney.

The tool that we have developed for the *Settore Sicurezza del Territorio* provides the foundation for monitoring the pollution caused by glass manufacturers and assisting them in complying with the provisions of the accord. The information in the pollution monitoring system can be graphically displayed and new data can be added easily. The system is composed of several different maps indicating the locations of companies, internal structures, chimneys, sewage lines, and sediment pollution data. These maps are linked to a database containing information on all the companies and types of pollutants.

The deadline for compliance with the environmental regulations is rapidly approaching. The glass manufacturers of Murano must initiate the actions necessary to meet these regulations to avoid being closed down. The pollution monitoring system we developed is a useful tool designed for the *Settore Sicurezza del Territorio*, but its benefits will be seen in how it affects the glass manufacturers of Murano. If our project has a role in helping the glass industry comply with environmental regulations, while preserving the rich tradition of glass making on Murano, we will have accomplished our goal.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

The purpose of this project is to work jointly with the *Settore Sicurezza del Territorio del Comune di Venezia* (referred to as the *Ecologia*) to help the glass manufacturers of Murano meet the environmental standards of the Italian government. The *Ecologia* asked us to develop a pollution monitoring system as well as a database for tracking company and pollution information. This system will initially be used to help the glass manufacturers of Murano come into compliance with the environmental regulations. Eventually the system will be used as a model for monitoring pollution of other industries on the whole island, and even beyond.

The island of Murano, in Venice, Italy, has a proud glassmaking tradition. Venetian glass, produced mainly in Murano, is known the world over for its quality, artistry, and unique design. Unfortunately, to produce such exquisite glass requires the use of many processes and materials that have an adverse effect on the environment.

Modern societies are conscious of these adverse effects and this has led to legislation regulating the output of wastes. Today, the glass manufacturers of Murano are being pressed to meet new environmental requirements brought on by the European Union, and in particular by the Italian government. If the manufacturers do not reduce the amount of wastes they release into the environment, they face being shut down.

In the past it has been difficult to determine the extent of pollution caused by the glass manufacturers. This is because some of the companies have been reluctant to cooperate with the government and accurate testing is difficult, due to the nature of the processes. Since gathering the data on the companies was difficult, it was nearly impossible to enforce the existing environmental regulations. In addition, if the *Ecologia* discovered that any of the manufacturers on Murano were breaking a law they were forced to report it to the main Italian government, who would revoke the manufacturers operating privileges. In May 2000, a law was passed by the Italian government allowing a grace period until the end of 2002 for the glass manufacturers of Murano to come into compliance with the regulations should they sign onto the accord. However, as a trade off, the existing environmental regulations were made more stringent. This law applied only to the glassmakers on the island of Murano and was introduced to keep the manufacturers operating while trying to meet the regulations. This made it possible for the *Ecologia* to become active in identifying and monitoring the manufacturers on Murano. The *Ecologia* is currently trying to prevent the closing of the glass manufacturing companies by gathering pollution data and offering possible solutions to help reduce emissions.

In order to aid the *Ecologia,* we constructed a pollution monitoring system that combined numerous types of data and information into one easy-to-use tool. To make the system as complete as possible, we have included information on company data and locations, plus information on noise, air, water, and solid pollution. We also made the system compatible with a previously existing system designed for the area of Marghera on the mainland near Venice. Our monitoring system is able to display any of the glass manufacturers or their buildings on Murano, data on air pollution emitted from chimneys, noise levels sampled from different areas of the island, sewer and wastewater effluents from glass manufacturing companies, and the levels of sediment pollution in the canals of Murano. All of this information can be displayed simultaneously or independently. The pollution monitoring system will provide information that will enable the *Ecologia* to get an accurate picture of the pollution problems on Murano, select future testing sites, and make plans to combat future problems. The system greatly simplifies the decision making process for the *Ecologia* by providing, for the first time, all of this information at the same time in the same place.

To design the pollution monitoring system we developed a common method of data entry and a database structure that would accommodate all of the information as well as any future additions that the *Ecologia* would like to include. At the same time, we had to work with the constraint that our system would be compatible with an already existing system for Marghera. We started by updating existing information on the glass companies by surveying the island of Murano. We then proceeded to design the database that would be the basis of the pollution monitoring system. Once the structure was finished, we were able to begin entering pollution data. We began with air pollution information from sixteen companies, provided by the *Ecologia*. We then incorporated building blueprints into the pollution monitoring system that were obtained from permits filed for settling tanks. The next step was to include existing data on the sediment conditions of the canals in Murano. Finally, we initiated a structure for the noise pollution data. The testing for noise levels will be finished after the end of this project, but the system is equipped to handle the data.

At the conclusion of the project we provided the *Ecologia* with the pollution monitoring system and database for tracking and visualizing the pollution caused by the glass companies on Murano. We also made recommendations on how to proceed with further testing and how to implement pollution abatement techniques that would only minimally disrupt the manufacturers' practices and traditions. In the future, this system will be used to model and monitor the environmental status of Murano.

2. BACKGROUND

This chapter provides information for the reader to understand the goals, methods, and results of the project. It contains a description of the island of Murano, a brief history of glassmaking on the island, and a discussion of traditional methods for making artistic glass. We provide information on environmental regulations in the United States, as well as the recent Italian laws relevant to the current pollution situation on Murano, and a survey of appropriate pollution abatement procedures. In addition, this chapter contains information about our project sponsor, the *Settore Sicurezza del Territorio del Comune di Venezia*, commonly referred to as the *Ecologia*, as well as background pertaining to pollution levels found on Murano. The pollution of concern on Murano is primarily from the glass manufacturers, known as the *vetrerie,* in the form of solid waste, atmospheric emissions, liquid emissions, and noise.

2.1. The Island of Murano

This section describes the island of Murano. It documents the location and interesting features of the island, and the economics of the island. Since Murano is famous for its artistic glass, this section also includes a brief history of glassmaking on the island.

2.1.1. ***Geography***

The island of Murano is situated 1.2 kilometers north of the city of Venice in the Venetian lagoon (see Figure 1) and is a part of the municipality of Venice. The island's 1134 acres are divided into four islands (Navagero, San Donato, Del Convento, San Pietro, and San Stefano) and two *sacche,* or reclaimed land zones, (Sacca Serenella and Sacca San Mattia) by a network of canals similar to that of Venice. Each of the islands and *sacche* are linked by several walking bridges and also by the *Azienda Comunale di Trasporti di Venezia* (ACTV) boatstops that are scattered along Murano's *Canale Grande* and the outer islands. The island as a whole has a layout remarkably similar to that of Venice. Murano has numerous *campi* (squares) like Venice; however instead of being centered around a church, the *campi* of Murano were

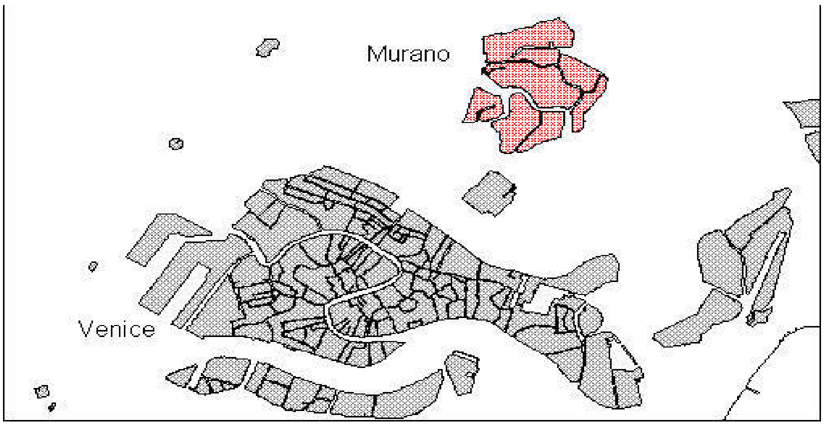

Figure 1 Map of Murano relative to Venice

originally centered around glass factories. The rest of the island is occupied by approximately 5,700 residents, and contains historical sites and businesses that cater to the needs of tourism. [1]

2.1.2. Island Demographics

The island first became inhabited during the fifth century when barbarian tribes paraded through the remains of the Roman Empire. As each new wave of invaders pushed through, populations in the lagoon area rose. Murano was no exception. The original occupants were mostly fishermen who made a living from the rich lagoon. However, the major development of the island occurred after 1291. It was in this year that the government of Venice ordered all the glass factories to be moved to the island of Murano. The main reason for this was that the glass factories were seen as a major fire hazard in a city that was built mostly out of wood and other combustible materials. [2] The inhabitants of Venice at the time were also unhappy with the smoke emitted from the furnaces. [3] Another, albeit unstated, reason was to help protect the knowledge and processes of glassmaking from spies of other countries. By this time glass had already become an extremely profitable export and the government took numerous measures to protect it. The highpoint in Murano's history was in the sixteenth century when an estimated 30,000 people lived on the tiny island. Today, about 5,700 people inhabit Murano. [4]

2.1.3. Economics of Murano

Murano is still dependent on the glassmaking trade for the majority of its income. This money comes not only from the sale of the glass products from the more than one hundred glassmakers still on the island, but also from the many tourists who flock to the island to see the traditional methods of glass production. Other businesses are also located on the island, and the majority of these, such as restaurants, cater to the tourists. Still other businesses such as dry cleaners and grocery stores are there for the convenience of the local inhabitants.

Figure 2 Church of Santa Maria and San Donato

As mentioned before, tourism is the other main industry of the island. Everything in Murano lives and dies by the tourists. On the average, ten million tourists visit Venice annually. Of these, many continue on to visit Murano. The glass shops depend on selling goods to these visitors as a major source of income. Most of the glass is purchased by tourists who come to the island to see the art of glassmaking.

[1] Encyclopedia Britannica.com. Murano. http://www.brittanica.com/bcom/eb/article/6/0/5716/55686+1,00.html (March 28, 2000)
[2] Lane, Frederic C. Venice A Maritime Republic. Baltimore MD: Johns HopkinsUniversity Press, 1973.
[3] Lazzarino, Graziana. Prego! Fourth Edition. McGraw-Hill Inc. New York. p. 182.
[4] Encyclopedia Britannica. http://www.britannica.com.

The restaurants on the island are there to feed tourists, and there are even two museums established to educate tourists about glassmaking and its rich tradition. The *fondamente* (main walkways along the canals) are lined with shops dedicated to the tourists. Though many of these are the small stores operated by the glass manufacturers, others include small cafes and restaurants designed to feed the visitors in between shops. Aside from the glass shops and furnaces, the islands two other main attractions are its two churches, the Church of San Pietro Martire and the Church of Santa Maria and San Donato. The latter was constructed in the 700s and rebuilt in the 1100s, while the Church of San Pietro Martire was built in the 1300s and rebuilt in 1511. Both attract many visitors annually.

2.1.4. Glassmaking

The term Venetian glass refers to glass produced in the city of Venice. Murano is part of the city of Venice, although it is not in Venice proper. Most glassmaking in Venice after 1291 occurred on Murano.

The glass trade is believed to have originated in the lagoon with the arrival of the first settlers. The glassmaking techniques of that time were all created in the Roman Republic. Originally, the Romans learned the techniques from the Syrians with whom they traded. It is believed that the Syrians were the originators of glassmaking. As the barbarian invasions began and citizens of the old Roman republic migrated to the lagoon, the glass techniques were brought with them. In the beginning, production centered mainly on religious pieces, such as glass objects for churches. These pieces of glass art were mainly donations to organizations such as the Benedictine church. [5]

The production of glass in Venice began to become a major industry during the thirteenth century. During this time the Venetian government began enacting and enforcing laws to restrict the master glassmakers to Venice and to prevent them from exporting their knowledge and materials. In 1224 twenty nine glassmakers were convicted of exporting their craft outside of Venice. The government regulated glassmaking tightly because it brought in substantial revenue. Production during this time focused on wine and oil bottles, and drinking glasses. However, religious artifacts were also still being produced. These centered around scenes depicted in color on glass. These pieces can be considered the beginning of artistic glass. Another important development during this time involved using manganese as a decolorizing agent. This allowed for clearer, nearly colorless glass. [6]

An important innovation during the medieval period was the introduction of eyeglasses. In 1302 glass workers had perfected the techniques of polishing and shaping glass to allow them to produce the first eyeglasses. This was a Venetian specialty and could only be obtained in Venice during this time. Another important innovation was the development of large rectangular sheets of glass for windowpanes. All previous techniques left a bulls-eye of raised glass where the glass was pinched off. Venetian

[5] Encyclopedia Britannica.
[6] Ibid.

glassmakers found a way to avoid this. An early use of this plate glass was in a lighthouse in Ancona in 1285.[7]

The Venetian glassmaking trade continued to increase profits and was considered on par with that of the Syrian glassmaking trade. However, in 1400, the Syrian capitol Damascus was conquered by invaders and the Venetian glassmakers became kings of their trade. This standing was further increased in 1450 with the discovery of how to make crystal. Crystal is much clearer than ordinary glass, and has a different structure. Crystal is created by the addition of certain additives to the glass in order to make its structure more uniform. With the introduction of crystal, Venice became known as the city with the best quality glass for over 200 years.

Other important innovations in glass by the Venetians were gilding, the production of mirrors, various colors and designs, and always the art form.

2.1.4.1. Traditions

The secrets of glassmaking were originally passed down from father to son, from generation to generation. These secrets were the livelihood of all involved, and as such were well protected. Master glassmakers were, and still are, unwilling to give out the secrets of their trade. Many of the traditions surrounding the manufacturing of glass are part of maintaining that secrecy.

Almost all glass producers joined the glassmaking guild. This was an organization not only for the masters, but also for the apprentices, helpers, and owners of the furnaces. These guilds set the rules by which all of their members operated. Prices, trade routes, techniques, compositions, and taxes were all established by the guild. This allowed everyone to compete fairly and also acted to protect the secrets of the trade.

Master glassmakers did not always own their furnaces, since it took an enormous amount of capital to set up a furnace. It was expensive to build the furnace and factory, and pay for the equipment, supplies and workers necessary to produce a quality product. Often a wealthy trader would establish a furnace and hire a master glassmaker.

As glassmaking enters the twenty first century it is becoming increasingly difficult for glassmakers to find someone to carry on the traditions. This is because of the amount of work involved and the working conditions. On average it can take twenty years of apprenticeship before a glassmaker is considered a master. In addition, working with hazardous chemicals and around high heat day in and day out is becoming less and less appealing. As a result, the number of master glass craftsmen is decreasing.

2.1.4.2. Hierarchy

At the top of the glass workers' hierarchy were the glass masters who ran each furnace. The masters knew how to produce many different types of glass and had their own formulas for each. Glass masters often specialized in one particular technique, doing it better than anyone else. The only limit to

[7] Encyclopedia Britannica.

what they could produce depended on their artistic talent. The next group in the pecking order was the *Garzoni*, which translates to 'boys.' These men were the helpers who were working their way to be masters. The *Garzoni* were hired by the glass masters to do individual tasks, and run the day-to-day operations of the furnaces. The next group was the *Garzonetti*, the 'little boys.' These were simply lower ranked helpers. Below the Garzonetti were the *Serventi* who performed menial tasks in and around the shops. Unrelated to this hierarchy, but just as important were the *Forcelanti* or glasscutters. They depended directly on the glass masters for business. They respected the masters and looked at them as teachers.[8]

2.1.4.3. Venetian Glass Today

Over one hundred and fifty glass manufacturers exist on the island today. Accompanying the manufacturers are numerous stores and showrooms. Glass companies on Murano have become a world provider, shipping their products across the globe. Many companies have sales offices all over the world. The business has increased, growing with the changing world of global economics. However, the craftsmanship still remains relatively untouched. Although the glassmaking industry of Murano is expanding, the number of craftsmen is steadily declining. Some glass masters are now multi-millionaires, but the life of a glass blower is not an easy or healthy one. A glass master will choose a relatively young adult to become his apprentice. The apprentice will work with the glass master day in and day out for approximately twenty years before earning the title of glass master. While working in the glass manufacturing environment, workers are subject to all of the pollutants that are created. Workers are constantly breathing in the fumes from the furnaces and from blowing glass. The long hours and health concerns can take away from the luster of becoming a master glass craftsman.

Glass manufacturing companies are approaching new times. Environmental regulations coupled with technological advances are constantly pushing the glass companies to modernize their factories. Glass companies must decide whether to accept change or maintain the traditional aesthetics associated with being a craftsman. Some companies are concerned that by implementing new technology that the tourists, public, and their customers will believe that they are no longer producing their glass by hand. The question arises as to how modernizing their companies will affect the manner in which their craft is viewed.

2.2. Glass Manufacturing

The history of glass and the work involved in the production of it can be summarized within the following quote:

"Glass is a hard substance, usually brittle and transparent, composed chiefly of silicates and an alkali fused at high temperatures. Metallic oxides impart color. In prehistoric times objects were fashioned

[8] Zampedri, Michele. History of Murano Glass. http://www.dofe.it/murano/muranol1.htm (March 26, 2000).

from natural glass such as obsidian (a volcanic substance) and rock crystal (a transparent quartz). The oldest extant manufactured glass is from Egypt, circa 2000 B.C. Many types of glass were made in Roman times, but little is known of European glassmaking from the fall of Rome until the tenth century. The materials are fused at high temperatures in seasoned fire-clay containers, boiled down, skimmed, and cooled several degrees; then the molten glass is ladled or poured into molds and pressed, or it is blown or drawn. The shaped glass is annealed to relieve stresses caused by manipulation, then slowly cooled. Until the seventeenth century, the finest glass was made in Venice. Later, France and England became centers of glassmaking. In the twentieth century, many new types have been developed, including fiberglass and safety glass. Despite mass production, glassmaking by hand remains a valued art." [9]

This section of the report informs the reader of traditional and modern methods of glass forming. The Corning Glass Museum's webpage, "A Resource of Glass," provided much of the information for the next five sub-sections. Unless otherwise noted, "A Resource of Glass" is the source for the information.[10]

2.2.1. Traditional Methods of Glass Forming

The traditional methods of glassmaking include: casting, core forming, cutting, and blowing. These methods allow the glassmaker to create various shapes and styles of glass. Below, we describe some of these methods and later explain the processes used in modern glass manufacturing.

2.2.1.1. Casting

Casting is the generic name for a wide variety of techniques used to form glass in a mold. Casting was one of the earliest methods used to make vessels and decorative objects and is still used today. Materials are mixed together and heated to the point of fusing. This composite, nearly glass-like, was cooled, ground into a powder, and may have been poured into a clay mold. The mold is placed in the furnace to "soak" in the heat until the powder melted into a viscous mass. As it melted, it "slumped" down in the mold. More powder had to be introduced at the top to prevent this. This process continued until the mold is full and all the powder melted. The hot mold and its contents are then removed from the furnace. Several hours later, when the mold and glass are cool, the mold is opened and the solid glass bottle-shaped object is removed. To be useful as a vessel, the solid glass has to be drilled-out and turned on a lathe to grind and polish the outside surface.

2.2.1.2. Core Forming

Core forming is the technique of making a vessel by trailing or gathering molten glass around a core supported by a rod. After forming, the object is removed from the rod and annealed. After annealing, the core is removed by scraping. This method was used by ancient glassmakers to produce

[9] Encyclopedia.com. Ask Jeeves Answer: Encyclopedia.com. http://www.ask.com (May 29, 2000).

small vessels. A shape made of clay is formed on the end of a metal rod. When it dries, the core is covered with molten glass drawn from a small crucible taken from a furnace. The glassmaker turns a dark colored molten glass from a crucible around a core until it is completely coated. Often a contrasting color is drawn around the first color from a second crucible. The glassmaker pulls a tool across the hot, soft bands of glass to make a wave-like pattern. When the core cools, it is carefully scraped out, leaving a useable bottle. In ancient Egypt, these bottles were probably used for perfumed oils. Common colors used to make these bottles were opaque blue, light blue, yellow, and white.

2.2.1.3. Cutting

Cutting, or glass grinding, is the technique whereby glass is removed from the surface of an object by grinding it with a rotating wheel made of stone, wood, or metal and an abrasive suspended in liquid.

Figure 3 Photo of glass cutting

2.2.1.4. Glass Blowing

Glass blowing is the technique of forming an object by gathering molten glass on the end of a hollow blowing pipe, and inflating it like a bubble. It can be blown into a hollow mold to form it or freely shaped with simple tools on the end of the blowpipe. Glass blowing greatly increased the production capabilities of glassmakers. With the introduction of this technique, glass could finally be mass-produced. Almost all modern artistic glass made in Murano is made by blowing. The master glassmakers take a molten glob of glass, and with the aid of gravity blow, snip and shape the blob into the desired figure or statue. Many of the common shapes can be made in a matter of minutes by any of the highly skilled masters.

2.2.2. Modern Glass Forming

Machines operating at tremendous speeds turn out tableware, bottles, cookware, laboratory-ware, tumblers, jars, window glass, auto headlight lenses, television tubes, and other products that we take for granted. When glass moves from the melting tank to the forming machine, the glass has the appearance of thick, red-orange syrup. All forming processes mold the glass quickly to the desired shape because, as the glass cools, it becomes rigid. Blowing, pressing, drawing, and rolling are the common forming methods. Centrifugal casting is employed for a few products.

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[10] Education Department of the Corning Museum of Glass. A Resource of Glass. http://www.cmog.org/Education/edglass.htm (May 30, 2000).

2.2.2.1. Pressing

Pressing provides greater dimensional control than blowing. Also, thicker cross sections can be accomplished. A sealed-beam automobile headlight lens is a good example of the capabilities of pressing, by which complicated shapes are formed to close dimensional tolerances. Pressing is done by loading a gob of molten glass into a mold. A plunger is then lowered and forces the glass to spread and fill the mold.

2.2.2.2. Drawing

Drawing produces tubing, rod, and sheet glass. Molten glass is drawn over a mandrel, a hollow cylinder, or a cone. Air blown through the cylinder keeps the tubing from collapsing until it becomes rigid. Tubing is drawn horizontally in the *Danner* machine, on a downward slant in the *Vello* machine, and straight up in the *updraw* machine. To make rods instead of tubing, the air pressure inside the mandrel is turned off.

2.2.2.3. Rolling

Rolling is used for some flat glass. Rollers are made with special alloys capable of withstanding the temperature of molten glass. It is a more rapid process than drawing, but the glass produced has a rougher surface. On occasion the rollers are embossed and produce a pattern in the glass.

2.2.2.4. Floating

In the floating process, sheet glass is formed by a special process and floated on a bath of molten tin held at a high temperature for a long enough time to produce a smooth fire-polished surface. Float glass does not require mechanical grinding and polishing because it is close to ground and polished plate glass in surface quality.

2.2.2.5. Centrifugal Casting

Centrifugal casting is employed for some special shapes. Molten glass flows into the mold while the mold rotates. Centrifugal force pushes the glass up the side of the mold, where it hardens, while the mold rotates. Conical sections of television picture tubes are manufactured in this manner. This method is sometimes called spinning, however, centrifugal casting should not be confused with spinning as used in metal forming, which is an entirely different process.

2.2.2.6. Finishing

Following forming and controlled cooling (annealing) some products require finishing operations. Some of these operations require reheating the glass and shaping by bending, sagging, pressing, or blowing. An additional annealing process must follow each hot operation.

2.2.3. Cutting

The technique of cutting is used for shaping solid glass, for both decorative and practical purposes, such as smoothing an edge. There are two methods that are common for cutting today.

2.2.3.1. Mechanical Cutting

Mechanical cutting consists of scoring the glass with a glasscutter wheel, then applying force across the score to produce a break.

2.2.3.2. Thermal Cutting

Thermal cutting employs a sharp flame to heat a narrow band of the glass. A jet of water is directed at the heated band causing a break. A type of thermal cut employs a ring of sharp flame that heats the glass until it softens and can be pulled apart. The open end of a tumbler is a good example of the smooth edge that a flame cut-off leaves.

2.2.4. Drilling

Drilling glass may be done by one of several methods, depending on the number of pieces to be produced and the accuracy required. Soft metal drills have a bit made of mild steel or another relatively soft metal. Such a tube is rotated while a slurry of loose abrasive grains and water is fed under the end of the tube. Tungsten-carbide drill bits work more rapidly and dimensional control is better than with a loose-abrasive drill. Diamond core drills are capable of the most rapid drilling rates and finest dimensional control. For large quantity work, diamond core drills are also the most economical. Initial cost is high but drill life is long with a high production rate. Finally, ultra-sonic drills are slow and used for irregularly shaped holes.

2.2.5. Processes

There are many raw materials that can be used to make glass. Nearly every known element has been used at one time or another in the manufacturing of glass. Silica sand is the principal ingredient and is combined with many other ingredients. The quality of the glass depends on how pure the original ingredients were. All materials are crushed and granulated to nearly uniform particle size, stored in batch towers, and fed into the melt tank in carefully measured amounts. Recycled glass, called cullet, is added to every batch. Temperatures up to 1600° C melt the batch and convert it into molten glass. The newly melted glass flows slowly toward the front, or the working end of the tank, where the "continuous feed" manufacturing machines are located. There, at the working end, the glass is cooled to a temperature that is suitable for forming the product.

Glass is an extremely complex substance. Manufacturers must pay special attention to the chemical composition of their batches. Due to the physical bonding structure of glass, one must ensure that the batch has been completely liquefied. After the batch has been completely liquefied, it must go through a cooling phase known as annealing. Glass is also capable of undergoing a coloring procedure.

2.2.5.1. Chemistry of Glass

Thousands of different chemical compositions can be made into glass. Different formulas affect the mechanical, electrical, chemical, optical, and thermal properties of the glass produced. There is no single chemical composition that characterizes all glass. Typical glass contains compounds divided into two different groups, prime materials (*materie prime*), and accessories (*accessorie*). The prime materials are composed of formers, fluxes, and stabilizers. Formers make up the largest percentage of the mixture to be melted. In typical soda-lime-silica glass, the former is silica (Silicon dioxide) in the form of sand. Fluxes lower the temperature at which the former will melt. Soda (Sodium carbonate) and potash (Potassium carbonate), both alkalis, are common fluxes. Potash glass is slightly denser than soda glass. The glassmakers on Murano mostly use soda ash, which is naturally abundant in the surrounding land. Stabilizers make the glass stronger and water-resistant. Aluminum oxide is an example of a stabilizer. Without a stabilizer, water and humidity attack and dissolve glass.

The accessory compounds are added to change the observable qualities of the glass. These include coloring agents, de-coloring agents, and agents which adjust the viscosity when the glass is being worked. These additives are where most of the compounds responsible for pollution are added to the mixture. However, these compounds are necessary to ensure the integrity and artistic quality of the glass.

2.2.5.2. Bonds

Glass differs from crystalline solids in that glass does not have a distinct melting point. In fact, glass is more like a liquid structurally, but unique enough that it constitutes its own state. This difference is explained by the fact that the chemical bonds holding the atoms together in a regular crystalline structure are identical. When the crystalline solid is heated, all the bonds break at exactly the same temperature. Below this temperature, called the melting point, the material is solid; above the melting point the material is a liquid. In contrast, the bonds in glass show a range of strengths. When glass is heated, these bonds break over a range of temperatures. As a result, glass softens gradually as it heats. It is convenient to describe the behavior of glass with temperature in terms of viscosity, the resistance of a liquid to flow. Starting as a liquid, the temperature is decreased. The material's ability to flow freely is gradually lessened. When the temperature is low enough to make the reciprocal of the viscosity of the material becoming glass near zero, the rigid structure called glass is formed.[11]

[11] Paul, A. Chemistry of Glasses. London: Chapman and Hall, 1982.

2.2.5.3. Annealing

Annealing is the process of slowly cooling a completed object in an auxiliary part of the glass furnace, or in a separate furnace. This is an integral part of glassmaking, because if a hot glass object is allowed to cool too quickly, it will be highly strained by the time it reaches room temperature and may break as it cools. Highly strained glasses break easily if subjected to mechanical or thermal shock. If a hot glass object is cooled too quickly it may be strained at room temperature, and therefore may break easily. For small, or thin-walled, shapes the effect may not be serious. For more massive pieces, the strain can be very serious. The amount of strain depends upon how quickly the object passes through a critical temperature range. The range depends on the composition of the glass but is usually about 450°C. If the glass is cooled slowly through that range, so that the temperature near the surface of the glass is never very different from that of the interior, then the strain in the resulting object is greatly reduced. [12]

2.2.5.4. Coloring of glass

Glass is colored by impurities in the batch ingredients, or by one of three processes; using a dissolved metallic oxide to impart a color throughout, forming a dispersion of some substance in a colloidal state, and suspending particles of pigments to form opaque colors. Of these methods, the intentional coloring of glass is usually accomplished by dissolving metals. The following table shows the colors generated when different metals are added to the glass paste. These metals are added to the paste in the form of metal oxides. The paste is a solid powder that usually resembles the color it will impart on the glass. [14]

Table 1 Metals and the colors they generate [13]

Metal	**Color**
Cerium	Yellow
Chromium	Green
Cobalt	Blue
Copper	Blue
Gold	Red
Iron	Green
Lead	White
Manganese	Purple (Usually After Exposure to Sun)
Nickel	Purple
Uranium	Yellow

The color a glass receives from a metal depends on the type of metal, the quantity, and the ionization state. Certain metals are well known to produce specific colors, and the intensity of the color is related to the amount of the metal present. Colors are created when the metal ions bond to the glass. The colors produced are a product of the metal used and its ionization state. There are detailed theories and calculations used to predict the color a specific metal ion will produce. [15]

[12] A Resource of Glass.
[13] Way, Al and Ginny. 162 Glass Insulator Color. http://www.come.to/162color. (April 10, 2000).
[14] Ibid.
[15] Paul.

2.2.6. Glass Manufacturing on Murano

The primary method of glass manufacturing used by the craftsmen of Murano is glass blowing. While most of the shaping is done by hand with simple tools, technology has also allowed craftsmen to use more modern methods such as grinding and core forming. These methods allow the glass makers to produce a variety of styles for such items as glasses, vases, and sculptures.

Figure 4 Traditional artisan working glass

2.3. Pollution in Venice

The processes used to make glass produce pollution. The metals used to color glass can be especially damaging to the environment if not properly disposed. Although Murano's glass manufacturers are not the only polluters of the Venetian lagoon, much concern exists for the cleanliness and healthiness of Venice's water. This section of the report informs the reader of the pollution that exists in the Venetian lagoon as well as pollution caused from the glass making industry.

2.3.1. Pollution in the City of Venice

Pollution in the Venetian lagoon is a threat to its wildlife and disruptive to industries like fishing and tourism. Hence, a clean lagoon is in the best interest of many in Venice. [16]

Air pollution has damaging effects on art. Particles in the air can fade, discolor, and chemically consume paintings and sculptures. The damage done to a work of art depends on the materials used to construct the piece, as well as the concentrations and types of pollution in the air.

Research done by Dario Camuffo, Peter Brimblecombe, and others at the Correr Museum has identified specific pollutants that cause damage to art in Venice. Soot, an organic material, blackens whatever it covers. However, it also acts as an absorbent for other gases, which then oxidize and damage the work of art even further. Calcium sulfate ($CaSO_4$), a pollutant caused in part by the calcium rich sea, is absorbed by soot and then oxidizes, causing even more blackening. Iron-rich particles catalyze sulfur dioxide (SO_2) into hydrosulfuric acid (H_2SO_4), which erodes materials. Chlorine, aluminum, and other pollutants can be deposited and do damage when chemically reacted.[17] Many of these air pollutants result from the combustion involved in several industrial processes.

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[16] World Press. "6/6 Mercury & Dioxins in Shellfish in Venice Lagoon." 6/6 Mercury & Dioxins in Shellfish in Venice Lagoon. http://www.greenpeace.org/ majordomo/index-press-releases/1996/msg00147.html (April 2, 2000).

[17] Camuffo, Dario. "Indoor air quality at the Correr Museum, Venice, Italy." The Science of the Total Environment. Vol. 236 Issues 1-3, September 15, 1999: p. 135-152.

2.3.2. Pollution Found on Murano

As in most parts of the world, the pollution on Murano exists in the form of air pollution, water pollution, noise pollution, and excess solid waste.

2.3.2.1. Air Pollution

Much of the air pollution in the Venetian lagoon originates in Marghera from the large chemical companies there, however a fraction is also emitted from Murano. This pollution is primarily caused by the nearly 150 operating glass manufacturers that work on the island. The furnaces used by the manufacturers in the melting and coloring of glass release many toxic emissions into the air. Most furnaces do not utilize chimneys; instead the emissions released from the furnace just vent out of the openings at the top of the buildings.

Figure 5 Photo of chimney and abatement apparatus

When attempting to monitor air pollution emitted from different sources it is necessary to have a concentrated path for the emissions to pass through. The emissions are then analyzed on the spot and the data recorded. When looking at air pollution for analysis scientists prefer to look at levels of chemicals being emitted, and the materials and processes that cause the pollution.

It is difficult to measure the levels of pollutants caused by each individual furnace on Murano because the emissions quickly dissipate into the atmosphere. The use of a chimney concentrates the emissions and allows for accurate measurements of the levels of pollutants released by the furnace. Also, because the emissions are concentrated, it is possible to utilize various methods of pollution abatement such as membrane filters in the chimneys. Once installed, membrane filters absorb many of the pollutants found in the emissions. Figure 5 is an example of a chimney connected to a pollution abatement device. In order to install a chimney the company must first get authorization, which requires that they present a construction plan to the building inspector. The building inspector then passes the proposal onto other groups such as the board of health and aesthetics board. Upon acceptance, the company is allowed to build the proposed chimney. The accord signed earlier this year mandates that companies utilize chimneys by the end of 2002, as well as utilize pollution abatement technologies to minimize atmospheric emissions. The use of a chimney is both beneficial and a nuisance. While they have many advantages in regards to pollution abatement and monitoring, chimneys add to noise pollution because the fans used to push the exhaust through the tubing create noise. The noise is especially noticeable at night when most companies are preparing their batches of glass for the next day.

2.3.2.2. Noise Pollution

Noise is another form of pollution caused by the glass manufacturers. Excessive levels of noise are created by the mechanical processes, such as grinding and cutting, used by the manufacturers of Murano. Another contributor to the noise pollution is the frequent use of pneumatic hammers to remove glass that has overflowed from the furnace. If the glass is not broken up quickly it bonds to the floor creating essentially a glass ice rink within the factory. Many homeowners in Murano have filed complaints about the level of noise created by the glass manufacturing companies located nearby. The machines that are often complained about include the *moleria* (grinders), chimneys(due to the fans), saws, and some mechanical cutting equipment. Often, only one of these machines can be heard at a time and even then the sound is overwhelming. When all of the machines are operating simultaneously it can be unbearable. While installing monitoring equipment in nearby houses we had several discussions with residents who described how loud and disturbing the noise from these machines could be; they say that when all the machines are turned on at once it can shake decorations off of walls. In order to get an idea of the sound levels to be discussed later in the results chapter, we include Table 2 for some common sound reference levels. It is important to note that a doubling in the level of decibels does not indicate a doubling in the loudness of the sound. Decibels are based on a logarithmic scale. Thus an increase of one decibel doubles the loudness of a sound. Using the examples from above the difference between a whisper and a classroom would be 1000 times. That is the classroom is 1000 times louder since it has a level thirty decibels higher.

Table 2 Common comparisons to decibel levels

Common Comparisons	Decibel Level
Threshold of hearing	0 dB
Rustle of leaves	10 dB
Average whisper (at 1 m.)	20 dB
City Street, no traffic	30 dB
Office, classroom	50 dB
Normal conversation (at 1 m.)	60 dB
City Street, busy traffic	70 dB
Noisiest spot at Niagara Falls	85 dB
Pneumatic drill (at 3 m.)	90 dB
Hi-Fi phonograph, 10W (at 3 m.)	110 dB
Threshold of pain	120 dB
Jet engine (at 50 m.)	130 dB
Saturn Rocket (at 50 m.)	200 dB

2.3.2.3. Water Pollution

The liquid waste created by the glass manufacturers causes another form of pollution. This waste can be seen in the sediments of the canals. Each building is connected to a series of sewers that eventually leads to the canals. The waste created by the glass manufacturers contains many of the heavy metals used to color the glass. The heavy metals are dissolved into the water when the workers clean the equipment and floors of the factory and during the grinding and polishing processes. The liquid waste eventually ends up in the canals via the sewers. Over time the heavy metals settle out of the water and combine with the sediments on the bottom of the canal. To prevent the waste from entering into the canals some buildings utilize septic tanks that store and filter out many of the pollutants from the water. This is accomplished by having a system of tanks where the first is filled with influent and solids settle out as the tank fills up. When it reaches a certain level it flows over to the next tank, where the particles continue to settle out. After making its way through the entire system, the water should be relatively free of particulate matter. These septic tanks must be maintained and emptied out periodically to ensure that they are performing correctly. If this is done, and the dry material is properly disposed, of the effluent water can be relatively clean. This is a common system installed in some of the companies on Murano, such as *Vetrerie Artistica Archimede Seguso*. While touring their facility we were able to see this type of system and discuss it with the company's owner. However, many companies do not have these systems, or some of the processes bypass the collecting drains. This untreated water is then released directly into the lagoon and joins the sediments in the canals.

Since, Murano does not have a developed public sewer system, it is extremely difficult to determine where pollutants originate before they enter the canals. Since there is a lack of public sewers, there is no easy way to test the effluent entering the canal. The only data available to determine how polluted the canals are was obtained by sampling the sediments in each canal. In future sections of this report we will deal with sediment pollution rather than water pollution for this reason.

2.3.2.4. Solid Waste

Solid waste is caused by the glass fragments that are not used in production as well as from the packing materials used in delivering products. Solid waste from the glass manufacturing industry is not a major contributor to the pollution found on Murano. The glass manufacturers collect and separate glass fragments according to color and eventually recycle the used glass. The used glass can only be used to form darker colors and therefore there is a limit to how it can be recycled. Glass that is incapable of being used again is shipped to waste management facilities located off the island. Waste from packing materials is collected and brought to a landfill located on the outskirts of the island. A lot of the packing that is used ends up as waste elsewhere after the products have been shipped.

Figure 6 Glass separated by color and ready to be reused or disposed

There is also pollution caused from residential and non-glass manufacturing companies located on Murano. However, the scope of this project is to focus on pollution caused by the glass manufacturing industry.

2.3.3. Pollutants from Glass Working

The pollution in the city of Venice is not entirely from the glassmakers. As stated before, Porto Marghera, an industrial center on the mainland, is the primary contributor of the lagoon's pollution. Glassmaking provides its share of pollutants, and a reduction in pollution in all areas will help.

2.3.3.1. Common Pollutants of Glass Manufacturing

Manufacturing glass is not a clean process. Many pollutants are released into the environment. Though the pollutants are released in small quantities compared to Marghera and other large industrial areas, they are out of proportion for the glassmaking industry. The exact pollutants and the amounts emitted from glass manufacturing vary greatly, depending on the process, purity of components, and desired glass color, strength, and other properties. There are some common methods to reduce pollution.

Glass is made from the combination of different materials that are combusted together at extreme temperature and fuse together. However, the combustion is responsible for the release of undesirable oxides into the atmosphere, such as carbon dioxide and carbon monoxide, as well as nitrogen oxides. The additives in the mixture are also emitted into the atmosphere during the combustion process. These often include nitrates, sulfates, lead, boron, chlorine, and fluorine. Nitrates, sulfates, and chlorine will also react with water to create acids, a serious environmental hazard. Limiting the amount of these substances in the glass mixture, though, will reduce pollution.

Methods have been developed to prevent or reduce the release of these pollutants into the environment. Lowering the melting temperature as much as the process will reduce pollution by limiting the amount of materials vaporized. Some pollutants may not even be created or released at lower temperatures. Other methods of reducing pollution involve recycling the heat produced and lost in the process, and using electricity as a heat source. This will limit the pollution caused by the burning of fossil fuels, a source of pollution in the glass manufacturing process not caused directly from making glass. Also, recycling unused or broken glass to be used in a new batch reduces pollution, because the majority of the pollutants are released during the initial melting. Placing precipitators, or scrubbers, in chimneys reduces air pollution by capturing solids before allowing the smoke and vapor to escape into the atmosphere.[18]

2.3.3.2. Hazards from Individual Chemical Pollutants

Some of the most toxic components of glassmaking are the substances used to add color. These are often heavy metals, which have a wide range of toxic effects on living organisms. In general, metals usually enter the human body through respiration or ingestion in the form of ionic species. Metals will strongly bond to proteins and body tissues. Many have a target organ in which the metal does the most harm and can accumulate. Toxins often target the liver and kidneys, because these organs are involved in

[18] A Resource of Glass.

the removal of harmful substances from the body. Toxic responses to metals, and other toxins, are usually only noted when a certain threshold is achieved causing adverse effects. Discussed here are some of the metals especially noted for their toxicity. Appendix K provides a more extensive list of metals used for coloring glass and their effects on human health.

Chromium is a metal that is necessary for metabolism in miniscule amounts. Unfortunately, when the metal forms a salt, it is often water-soluble and can be easily absorbed by the lungs and bloodstream. Chromium is a known carcinogen, causing lung cancer.

A metal that is extremely cumulative in the body is cadmium. The kidneys are especially sensitive to the metal, but it can also cause pneumonia, inflammation of the lungs, and disabling emphysema. Cadmium is a suspected carcinogen, being linked with prostate and renal cancer.

Mercury is a very dangerous metal. In addition to absorption through inhalation and ingestion, mercury can enter the bloodstream through the skin. When in the body, mercury targets the brain and kidneys. Psychopathological symptoms can follow due to impairment of metabolic processes in the brain.

Often absorbed through the lungs, lead is a metal that cumulates in the bones. Lead is known to cause anemia and damage to the central nervous system.

Arsenic is another dangerous element. It can enter the body through respiration, ingestion, and, for certain compounds, skin contact. Arsenic can inhibit metabolic activities and cause general illness effects. Large quantities can cause shock, even death. In addition, arsenic is known to increase the chance of lung and skin cancer. [19]

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[19] Manahan, Stanley E. Toxicological Chemistry. Chelsea, MI: Lewis Publishers, Inc., 1989.

2.4. Pollution Abatement Techniques

A step towards reducing pollution is the proper disposal of waste. Table 3 lists the proper methods of disposing several metals used in the manufacturing of glass. These disposal methods are for the pure component and its compounds, or a solution of these heavy metals. [21]

Table 3 Metals and suggested methods of disposal [20]

Metal	Suggested Method of Disposal
Arsenic	Place in long term storage container and return to supplier. Arsenic trichloride ($ArCl_3$) can be hydrolyzed to arsenic trioxide (ArO_3) using scrubbers for hydrochloric acid (HCl) abatement
Cadmium	Cadmium fluoride should be precipitated with soda ash or slaked lime and sent to a chemical waste landfill. Other products should be precipitated into sulfides, dried and sent to suppliers for reprocessing.
Chromium	Reduce chromic acids to chromium (III) and precipitate by pH adjustment. Chromic fluoride and chromic sulfate must undergo alkaline precipitation and neutralization. Dispose both in chemical waste landfill. Recovery and recycling is a viable option.
Copper	Copper wastes can be concentrated and the copper can be electrolytically removed and sent back to supplier. Copper can also be precipitated and disposed of in a chemical waste landfill.
Cobalt	Cobalt chloride is reacted with water, caustic soda, and slaked lime. Precipitant is safe to be placed in landfill. In general, cobalt wastes should be recovered.
Iron	Safe for landfill, or iron may be recovered.
Lead	Convert lead oxide (PbO) to a sulfide, with HNO_3, and recover for reprocessing by supplier. Also safe to dispose oxide in landfill.
Manganese	Manganese metal should be disposed of in a sanitary landfill. Manganese chloride and sulfate must undergo conversion to oxide before disposing in landfill.
Mercury	Accumulate for resale or for reuse.
Nickel	Nickel antimonide, nickel arsenide, and nickel selenide (use of which is likely rare, if existent, in glassmaking) must be encapsulated and disposed of in a chemical waste landfill. Most other nickel wastes can be recovered and recycled.
Silver	Recovery is best. This can be achieved by photoprocessing and electroplating.
Tin	For $SnCl_4$, pour onto sodium bicarbonate and spray with ammonium hydroxide and add crushed ice, then it is safe to flush down a drain
Uranium	Recover waste uranium for reprocessing by supplier.

There are also general methods of reducing metal waste. Recycling and reusing metal wastewater whenever possible will reduce the total amount of metals used. This is also an easy and economical

[20] Sittig.
[21] Sittig.

solution. In addition, more efficient resource management can greatly reduce metal waste. Identifying ways to modify production processes can reduce pollution and save the company capital. Technology does assist in general waste reduction procedures. There are also advanced technological solutions to reduce metal wastes. It is these technologies that will be discussed in the following sections.

2.4.1. Activated Carbon Adsorption

Activated carbon is a carbon compound with hundreds of small internal holes that are large enough to trap ions, metals, and small particles. The interaction between the substrate and the carbon then locks the substrate in place. This system can be used to trap organic compounds as well as metals that are dissolved in water. Adsorption is when thin layers of molecules of liquid or gas chemically attach to the surface they are bound to.[22]

For every gram of activated carbon there is anywhere from 500 to 2000 square meters per gram of area to trap particles. The particles that are trapped can then be released as well. This is very advantageous in that the metals produced in the wastewater of glass manufacturers can be trapped, removed from the water released in a separate container using an acid, and the carbon reused. If the different metals are released in different effluent streams from the shops then the individual metals could even be reused.[23]

There are many conditions that influence the effectiveness of this system. First, the degree of solubility of the substrate, the material the activated carbon is attempting to collect. The more soluble the substrate the easier it will be adsorbed. The second factor is the pH of the water. The third factor is the temperature of the system. As the temperature rises, the effectiveness of the system decreases. [24]

When considering the use of activated carbon adsorption the above factors should be evaluated in addition to the isotherms for the selected components one is attempting to remove. An isotherm is a graph of solubilities that is used to evaluate the feasibility of using carbon adsorption to remove a substrate effectively. In addition the isotherms can tell users how much carbon is necessary to remove the given concentrations, and how often the carbon may need to be replaced. The most commonly used isotherms are the Freundlich and Langmuir isotherms. However, adsorption improves greatly at higher concentrations, and in general, the steeper the slope of the isotherm, the greater the efficiency of removal of the carbon in the column. [25]

Carbon adsorption can be achieved in one of two ways: fixed-bed adsorption systems and moving-bed adsorption systems. The fixed-bed adsorption system employs gravity to move the contaminated ground water through the carbon bed.

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[22] Freeman H.M. ed., Standard Handbook of Hazardous Waste Treatment and Disposal, (New York McGraw Hill Book Co. 1998), p. 6.3.
[23] Freeman, H.M. p. 6.5.
[24] Ibid. p. 6.4-6.11.
[25] Ibid.

The moving-bed carbon column is operated with one or more columns in series. In this application the influent (liquid coming in) contaminated water enters the bottom of the first column and is uniformly distributed over the bottom of the column. The groundwater flows upward, through the column, and the effluent, (liquid exiting) is then, collected by a screen in a second manifold, at the top of the column. After collection in the first tower, the effluent then flows to the bottom of the next column, and the cycle repeats itself. The liquid flow through the columns is not continuous, but is instead pulse wise.[26]

The cost of this system is low to install and to maintain. Though costs will vary by machinery, installation, and use, a good average can be obtained. The costs are based on the amount of carbon needed for the system. The capital equipment was estimated to cost about $12 per pound of carbon and $1.50 per pound for thermal regeneration of the carbon in 1989. If the carbon is not regenerated then it could cost twice as much to purchase new carbon each time. [27]

2.4.2. Electrolytic Recovery Techniques

Electrolytic recovery techniques were designed specifically to remove metals and metal ions from waste streams. Electrolytic refers to the use of electricity to remove something. In common practice a bed of cathodes (+ terminals) and anodes (- terminals) are placed in the path of the wastewater. When electricity is applied the metal ions are returned to their elemental form at the cathode. This system is used to separate metals from waste, and enables them to be recovered very easily in their pure form. The metals could then be resold or reused.[28]

The electrolytic process works based on the oxidation-reduction reactions that occur at the cathode. When the electrical current is applied the metals are returned to their pure elemental form on the cathode. Simultaneously, at the anode gases such as hydrogen, oxygen and nitrogen could be released. The gases that form at the anode depend on the chemicals in the waste stream. This process has already been used in industry to recover gold, silver, cadmium, zinc, copper, nickel and works with the other metals listed in Table 1. Though the recovery of pure metals is only accomplishable if the waste stream contains only one metal, the technique will still remove the other metals. The metals could then be sealed and properly disposed of.[29]

There are several different technologies available to accomplish the electrolytic removal of metals. Their differences lie in the concentrations of the metal at which they are most efficient. The normal system works best in high concentrations of metals usually above 20mg/l. However, the ESE, or extended surface electrolysis system works better at lower concentrations on the order of under 10mg/l. [30]

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[26] Freeman, H.M.. p. 6.8-6.11.
[27] Ibid p. 6.17.
[28] Ibid. p. 6.38.
[29] Ibid. p. 6.38-6.39.
[30] Ibid. p. 6.43.

The equipment needed for this process consists of the electrochemical reactor and electrodes, a venting system for the gas, re-circulation pumps, and a power supply. In addition to requiring little equipment there are several other advantages to this technique. The initial investment for this process is low, the maintenance fees are low, there is no toxic sludge to dispose of, and the metals could be recovered and sold.[31]

The most common uses of these systems so far have been in the electroplating industry where the metals recovered can then be reused. In Denmark in 1996, a researcher conducted a study on how the electroplating industry managed to comply with environmental regulations. The electroplating industry uses metals more extensively than the glassmaking industry, since metal is the desired product in electroplating while metals are only an additive in glass. The study found most electroplating firms had a cost of 1-2% or 4-5% of their annual turnover. It would be reasonable to expect proportional, or smaller, costs for glass manufacturers.[32]

2.4.3. Ion Exchange

Ion exchange systems use resins to remove metals from wastewater run through the machinery. The operating costs of these machines are extremely low, so the initial investment would be the only considerable cost. However, currently we have no evidence that the resins will be able to remove the metals involved in glassmaking. Most current ion exchangers work with nickel, copper, and chromium from the electroplating industry. In addition this technology is not the final step in hazardous waste removal from wastewater as it often produces chemical waste, which then must be neutralized and disposed of. Essentially the ion exchange machinery would remove the metals and concentrate them in the resin. The resin would then be washed with an acid releasing the trapped components into a storage bin. This must then be properly neutralized and disposed. Ion exchangers do not permit the materials removed to be recycled either. Finally, as shown in Figure 7 these machines are somewhat large and heavy and may not be practical to install in the old buildings in Murano. In addition many of the companies do not want to install this technology as it takes away from the traditional appearance of the industry. This is currently not a recommendable option for use in Murano.[34]

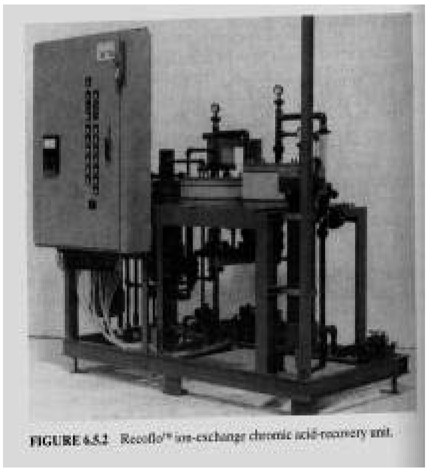

Figure 7 Recoflo ion exchange machine [33]

[31] Freeman, H.M. p. 6.41.
[32] Christensen, Per and Susse Georg. "Regulatory Effects in the Electroplating Industry –A Case Study in Denmark." J. Cleaner Prod. Vol. 3, No. 4 (1995): p. 221-224.
[33] Freeman, H.M. p. 6.64.
[34] Ibid. p. 6.57- 6.70.

2.4.4. Membrane Systems

A membrane is a specially designed semi-permeable barrier that acts as a filter to some materials, but not to others. The design of these systems developed from biological research and many synthetic membranes have since been produced. There are several different categories of membrane systems. However, each operates on the same basic principle. First, there is the membrane filter that separates based on size and shape, ionic or nonionic, or a combination of the two. Second, the purpose of each system is the same to purify the liquid phase, reduce wastes, concentrate wastes, or recover the solute. There are three main types of membrane filtration, which pertain to this project: reverse osmosis (RO), hyperfiltration and ultrafiltration.[35]

Osmosis is the process by which water moves from an area of lower concentration of solute to greater concentration of solute in an attempt to equalize the concentrations. The process of reverse osmosis is going to push this one step further and drive all of the water or other liquid phase through the membrane system to leave the solutes behind. In order to accomplish this external pressure will have to be applied in order to prevent the water from following normal osmotic tendencies. There are several systems currently commercially available for RO. All of these systems have the same key benefits. First, in some cases the recovered solvent and solute can be recycled and either reused, or sold. Second, the separation process is not energy intensive. Third, capital costs are relatively low. The cost of membrane materials has remained relatively stable over the past two years making these systems economically viable with other systems. Finally, RO equipment does not require much space, and is a straightforward mechanical process. Almost no operational skills are needed to operate the system.

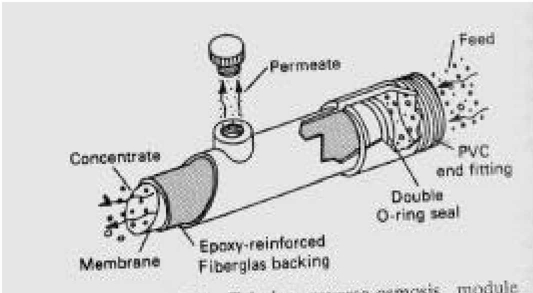

FIGURE 6.7.1 Tubular reverse-osmosis module (*U.S. EPA*)

Figure 8 Tubule membrane module. [36]

Two of the systems currently available include tubule modules, and spiral wound modules. In the tubule design shown in Figure 8 the membranes are inside of a tube the size of which could be inserted into a standard drain. The feed liquid is pumped in through one side. Once inside, the tube exerts a pressure forcing the solute to separate form the feed. The concentrate (which is the majority of the solute) exits the other end of the tube and the permeate (or cleaned solvent) exits through the side of the tube. The spiral wound design shown in Figure 9 works in much the same manner as the tubule module, except that both the concentrate and the permeate are let out at the same end. In the spiral wound method the feed is pumped in through one end. As pressure is exerted from the outside the

[35] Freeman, H.M. p. 6.86.

materials in the feed stream are stopped by the layers of membrane and pass through the module. However, the permeate makes its way to the inner hollow tube and passes out through here. After both of these processes the concentrate could then be properly retained and either recycled or returned to the manufacturer. RO systems have been shown to be effective removing organic salts, and inorganic ions (specifically heavy metal ions). If the metals from the glass industry were not in ionic form it would first be necessary to oxidize them in order to use these techniques. [37]

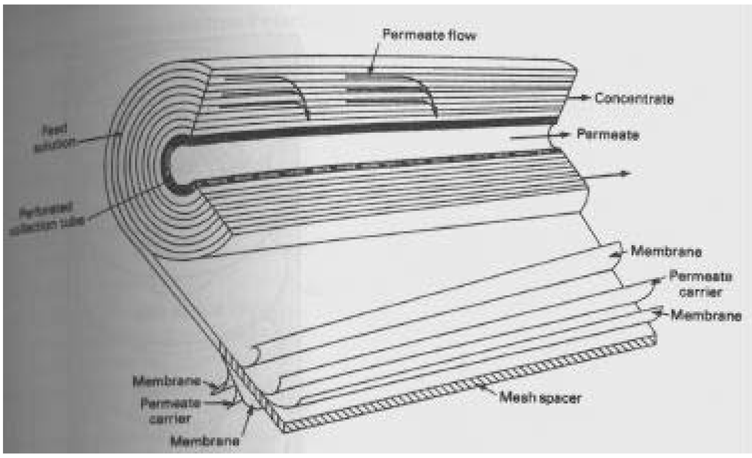

Figure 9 Spiral wound module [38]

Hyperfiltration and ultrafiltration are very similar processes. The only difference is the siz e of the compound the systems separate. Hyperfiltration works on compounds with molecular weights between 100 and 500, while ultrafiltration works on compounds with molecular weights greater than 500. Both of these systems can use the same modules described earlier in RO. However, instead of sorting ionic species these membrane filters remove compounds based purely on size. The most common membranes used for these systems are polysulfone and cellulose acetate materials. Of the two polysulfone is much more versatile as it can work in temperatures from zero to seventy nine degrees Celsius and in pH ranges form 1 to 13. The polysulfone membrane can also be cleaned by a greater number of cleaning agents than the cellulose acetate membrane. Hyperfiltration and ultrafiltration are also currently being used commercially to remove heavy metals from wastewater.[39]

All of the membrane systems discussed here are susceptible to fouling. Fouling occurs when large suspended solids enter the devices and clog the membranes preventing them form doing their jobs. It may be necessary to put a filter in the feed path to prevent suspended solids from clogging up the membrane systems.

2.4.5. Chemical Precipitation

Chemical precipitation is a process in which a chemical is added to the waste stream in order to make compounds dissolved in the stream precipitate (fall out of solution). Chemical precipitation has

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[36] Freeman, H.M. p. 6.88.
[37] Ibid. p. 6.87-6.89.
[38] Ibid. H.M. p. 6.89.
[39] Ibid. p. 6.94-6.95.

been shown to be effective in removing arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver from contaminated water.[40]

The first step in chemical precipitation is to direct the waste into the stirring container. Here a chemical precipitating agent is added to the waste and the mixture is stirred. The precipitating agent "clumps" to the material and the larger complexes are separated out by settling in a clarifier. Flocculating agents may be added to the mix in order to further the settling. These agents group the clumps together into even larger complexes. The larger the complex, the less soluble it becomes in the waste stream. The water is then let out of the clarifier and the materials in the flocculent are drained out as a sludge that then must be processed.[41]

Some of the chemicals used as precipitating agents for metals include hydroxides (both calcium and sodium hydroxides), sulfides, and some as carbonates. In each case the amount of metals present in the effluent (the "clean" material leaving) depends on several factors including solubility, temperature, and pH of the solution. By using hydroxide precipitation it is possible to get concentrations of metals in the effluent of 1mg/L and even as low as .1mg/L in optimal conditions. Sulfide precipitation has a few advantages over hydroxide precipitation. First, the inherent solubility of the complexes are much lower. This means that more will settle out. In addition hexavalent chromium can be precipitated in this manner without prior pretreatment. Sources of sulfides include sodium sulfide, sodium hydrosulfide, and ferrous sulfide. One problem with sulfide precipitation is that there is a possibility, if the pH drops, of producing hydrogen sulfide gas that is highly toxic to humans. Also there may be excessive release of sulfide in the effluent since excess sulfides must be added in order to drive the reaction to completion. This method produces effluent concentrations on the same order as hydroxide precipitations (i.e. on the order of between .1 mg/l and 1mg/l are achievable). There are numerous other precipitation techniques that should be looked at as well if this method is to be used in Murano. When choosing the proper compound to act as a precipitant it is important to conduct tests first to make sure that it is the correct agent.[42]

2.4.6. Other Technologies

Recently, Techneglas, Inc. of Pennsylvania has developed a process that eliminates the need for lead and other additives in making glass for their cathode-ray television tubes. This new process, requiring the installation of a new furnace, does not impair the physical properties of the glass and greatly reduces waste and pollution. For example, the emission of nitrogen oxides was reduced by fifteen percent. Due to the efficiency of the process, the company has saved over $2 million a year since installing the furnaces. Techneglas installed their first new furnace for the process in 1989, followed by adding another in 1994 and again in 1997. The success of Techneglas' process gives those concerned

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[40]. Freeman, H.M. p. 7.20.
[41] Ibid. p. 7.21.
[42] Ibid. p. 7.20-7.27.

about the environment hope that similar technology can be developed for other areas of the glass industry. [43]

Acids are sometimes used to etch glass. The most effective and common acids are hydrochloric acid (HCl) and hydrofluoric acid (HF). Caution must be used when disposing the excess or wastes of these acids. If not reused, acids should be neutralized before disposal. The most common and cost effective way of neutralizing acids is through the use of sodium bicarbonate ($CaHCO_3$). When the acid is poured over the $CaHCO_3$ it produces carbon dioxide (CO_2) gas and the halogenated calcium salt. For example the HF and HCl acids used in glassmaking would form calcium fluoride and calcium chloride respectively. These salts which would be recoverable from the bottom of the vat are very stable and can be disposed of easily.

There are many technological options for pollution abatement. Due to the limited size of many of the facilities on Murano, space is a priority. If larger sized technologies are needed, perhaps a community facility is in order.

2.5. Environmental Regulations

In recent history, governments have identified the need for an organization to create and enforce legislation for the protection of the environment. In the U.S., the Environmental Protection Agency (EPA) was created to fulfill this role. Europe took a similar approach in creating the European Environmental Agency (EEA).

2.5.1. Environmental Protection Agency (EPA)

In 1970, United States President Nixon sent a special message to Congress regarding reorganizing the government's environmental efforts. In this message, he pointed out that the government's environmental response systems are spread out over a wide range of agencies, whereas most environmental issues require that these agencies work in total synchronization. To correct the lack of coordination between agencies, he proposed the creation of the Environmental Protection Agency. The EPA approaches pollution control with a much more effective system than was possible at the time.

The EPA:

1) Identifies pollutant agents.
2) Traces them throughout the environment.
3) Determines the total exposure of man and environment to harmful substances.
4) Examines interactions between agents.
5) Identifies where appropriate action can be taken.

[43] Pennsylvania Department of Environmental Protection. "Pollution Prevention Success Story Techneglas, Inc., Pittston, Luzerne County." Pollution Prevention Success Story. http://www.dep.state.pa.us/dep/deputate/fieldops/ne/PPC_News/PPSucces.htm (April 25, 2000).

This agency brings into one place the research, monitoring, rule making, and enforcement that were previously spread out over six agencies.

2.5.2. EPA Regulations

The EPA is empowered to act on a variety of environmental laws but most relevant are the National Environmental Policy Act, Clean Air Act, Clean Water Act, Pollution Prevention Act, Resource Conservation and Recovery Act, and Toxic Substances Control Act.

The National Environmental Policy Act of 1969 establishes the EPA. The purpose of the policy, as defined by the act, is to encourage harmony between man and nature, prevent and eliminate damage to the environment and human health by man's actions, and understand the importance of nature [44].

In 1970, the Clean Air Act originally passed as a response to an international agreement on air pollution. This law regulates sources of air pollution through controls and permits. In 1990, the act was amended to strengthen permit requirements and controls over air pollution. [45]

Originally focusing on municipal wastewater treatment systems, the Clean Water Act now has a wider jurisdiction. The law requires permits for industrial discharge. [46]

The Toxic Substances Control Act (TSCA) authorizes the EPA to prohibit the use and manufacturing of certain high-risk chemicals. Passed in 1976, the law allows the EPA to declare a chemical unreasonably dangerous to the environment and human health and prohibit its use. [47]

The Resource Conservation and Recovery Act (RCRA) was passed in 1976 to hold producers of hazardous wastes accountable for their proper disposal. This law was presented due to the trend of the dangerous dumping of wastes with damaging effects to the environment and human health. [48]

In 1990 Congress passed the Pollution Prevention Act. This act emphasized federal commitment to pollution prevention rather than to funding cleanup. The act emphasized the EPA's role in educating, raising awareness, training, and information exchange.

2.5.3. European Environmental Agency (EEA)

The European Environmental Agency was formed to streamline environmental operations and connect the operations of all of the European Union member nations. In 1990, the European Council passed Council Regulation (EEC) Number 1210/90, setting the legal backdrop for what would become the EEA. This regulation provided for the collection, processing, and analysis of environmental data at the European level in order to enable the Community and member states to make informed decisions.

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[44] U.S. Congress, National Enivironmental Policy Act, 1970 (can be found at http://es.epa.gov/oeca/ofa/nepa.html)

[45] Freeman, Harry M. Standard Handbook of Hazardous Waste Treatment and Disposal. New York: McGraw-Hill, 1998.

[46] Ibid.

[47] Ibid.

[48] Ibid.

Recently, Council Regulation (EEC) Number 933/1999 passed and more clearly defines the EEA's functions.

The EEA has four main areas of functionality: networking, monitoring, reporting, and acting as a reference center. The goal of networking is to interconnect already existing institutions through the Environmental Information and Observation Network (EIONET) so that Europe-wide data gathering and processing is possible. Delivering comprehensive environmental analysis from the data gathered with EIONET and then serving as a repository for this data are the other responsibilities of the EEA. This is very similar to the EPA's mission except that the EEA does not enforce on its own. The role of the EEA is strictly advisory.[49]

2.5.4. EEA and Italian Regulations

Like the EPA, the EEA and Italian government have enacted a variety of laws to protect the environment. These laws encompass protecting the soil, water, and air from pollutants.

The current regulations on air emissions come from a law passed in 1990. DM 12/07/90 established limits for air emissions for all of Murano based on a yearly production of 13,000 tons of glass. The first two columns of Table 6 (shown on page 39) provide the data pertinent to this legislation.

The sediments in Italy are classified into four classes depending on the concentrations of twelve pollutants. These levels were set by *Protocollo del Ministero dell' Ambiente* April 1993. This information is

Table 4 Italian sediment classes

Pollutant	Class A	Class B	Class C	Class D
Hg	0.5	2	10	>Class C
Cd	1	5	20	>Class C
Pb	45	100	500	>Class C
As	15	25	50	>Class C
Cr	20	100	500	>Class C
Cu	40	50	400	>Class C
Ni	45	50	150	>Class C
Zn	200	400	3000	>Class C
Total Hydrocarbon	30	500	4000	>Class C
IPA	1	10	20	>Class C
PCB	0.01	0.2	2	>Class C
Pesticides	0.001	0.02	0.5	>Class C

shown in Table 4. The values depicted are for milligrams per kilogram of dry sample weight. In order to be classified into A, B, or C class sediment the measured value must be less than that in the columns shown. The Italian government has regulations for noise pollution. The level of noise an entity may make depends on the region's zone and the company, factors that determine which of six *classi* (classes

[49] European Environmental Agency, Council Regulation (EC) No. 933/1999, 1999 (Luxembourg).

such as commercial, industrial, residential, or mixed) pertains to the business. The time of day is also important in what level of noise is within legal limits. Table 5 refers to the current legislation, namely 89/391/CEE, 89/654/CEE, 89/655/CEE, 89/656/CEE, 90/269/CEE, 90/270/CEE, 90/394/CEE, and 90/679/CEE. Class III zones cover most of Murano. This zone is for an area of mixed residential

Table 5 Noise level regulations[50]

Classi di destinazzione d'uso del territori. (Type of area sampled)	Tempi di rifermento (level)	
	Diurno (6.00-22.00) Day (dB)	Notturno (22.00-6.00) Night (dB)
Valori limite di emissione (limits of emission)		
I aree particolarmente protene (protected area)	45	35
II aree prevalentemente residenziali (residential area)	50	40
III aree di tipo misto (mixed res. and ind.)	55	45
IV aree di intensa attivita umana (area with lots of human activity)	60	50
V aree prevalentemente industriali (area predominated with industry)	65	55
VI aree esclusivamente industriali (exclusively industry)	65	65
Valori limite assoluti di immissione (limits of emissions indoors)		
I aree particolarmente protene	50	40
II aree prevalentemente residenziali	55	45
III aree di tipo misto	60	50
IV aree di intensa attivita umana	65	55
V aree prevalentemente industriali	70	60
VI aree esclusivamente industriali	70	70
Valori di qualita (quality values)		
I aree particolarmente protene	47	37
II aree prevalentemente residenziali	52	42
III aree di tipo misto	57	47
IV aree di intensa attivita umana	62	52
V aree prevalentemente industriali	67	57
VI aree esclusivamente industriali	70	70

and industrial occupation.

2.5.5. *Regulations on Murano Glass Manufacturers*

On April 18 the Italian govenernment signed an agreement that impacts the glass manufacturers of Murano. The agreement was the *Accordo di Programma per il Miglioamento Dell'impatto Ambientale Generato dalle Aziende Produttrici di Vetro Artistico Situate Sull'isola di Murano-Venezia* (Accord for the Program to

[50] Gazzetta Ufficiale della Repubblica Italiana. Serie Generale No. 280. 12/1/97.

Minimize the Environmental Impact of the Businesses who Produce Artistic Glass on the Island of Murano, Venice). The companies that signed on to the agreement have until December 31, 2002 to comply to all existing environmental legislation. In addition, they must comply with new, more stringent, atmospheric emissions instituted by the Italian government in exchange for delaying the deadline. This allows nearly three years to achieve the new standard. If companies do not sign on to the agreement, they would be expected to meet the new regulations immediately. If they do not meet regulations, then they would be closed down. In effect the law provides almost a three year grace period for the manufacturers to remain open. This bill is a protective measure by the Venetian government to enable the traditional artistic glassmakers to remain open while trying to meet the new regulations. Table 6 compares limits for air pollutants in Murano in 1990 and what the agreement requires to be achieved by December 31, 2002. These levels are maximums that all the glass manufacturers can produce as a collective whole. The levels allowed must be reduced in most cases by 50% and some by as much as 90%. This is a big step especially for companies who were not in complinace with the regulations from 1990.

Table 6 Tons per year of each pollutant

Inquinanti (Pollutant)	DM 12,07.90 (Limits of July 12 1990)	All'Accordo di Programma (Levels allowed by the accord)	Miglioramento dal DM 12,07.90 (Percent reduction from 1990)
	Metric tons per year	**Metric tons per year**	**(%)**
Ossidi di azoto (Nitrous Oxides)	2527	870	65
Polveri totali (particulates)	158	42	73
Cloruri (come HCl) (Chlorines (like HCl))	32	21	34
Fluoruri (like HF) (Fluorines (like HF))	5.3	4.2	21
Cadmio (Cadmium)	.21	.11	48
Arsenico (Arsenic)	1	.53	50
Cromo (Cromium)	1	.53	50
Cobalto (Cobalt)	1	.53	50
Nichel (Nickel)	1	.53	50
Selenio (Selenium)	1	.53	50
Antimonio (Antimony)	5.3	.53	90
Manganese	5.3	.53	90
Piombo (Lead)	5.3	.53	90
Rame (Copper)	5.3	.53	90
Stagno (Tin)	5.3	.53	90
Produzione di vetro stimata (estimated glass produced)	13,000	13,000	

Individual companies must sign on to the agreement, and the government is putting pressure on them through the media. Once they sign on, the glass manufacturers have six months to produce a plan deciding how they will reach the new environmental regulations. The agreement does not offer environmental solutions for the companies, only goals. Government officials will regularly check on the glass manufacturers progress, though.[51]

[51] Environmental Department of the City of Venice, Accordo Di Programma Per Il Miglioramento Dell'Impatto Ambeientale Generato Dalle Aziende Produttrici Di Vetro Artistico Situate Sull' Isola Di Murano-Venezia, 1999 (Ven1ice, Italy).

2.6. The *Ecologia*

Our project sponsor, the *Ecologia*, is a department of the *Comune di Venezia*. The *Comune* is the government body that manages the city of Venice. The *Ecologia* is the branch of the government concerned with environmental issues.

The *Provincia*, the provincial authority, enacts and enforces environmental law and regulation. Venice is a part of the *Provincia di Veneto.* The *Ecologia*'s interest lies in trying to ease new regulations into the area to better serve the industries, as in the instance of the accord recently passed concerning glass manufacturers. They are allowing the glass manufacturers some extra time to comply, recognizing the difficulty and importance of trying to preserve an artistic tradition while meeting modern legislation.

The information contained in the background will be incorporated into the analysis of possible pollution prevention measures. This information enabled us to create a system for the monitoring of pollution on Murano that will allow the Ecologia to aid the glass manufacturers in meeting the environmental regulations without infringing upon the age-old traditions.

3. METHODOLOGY

This chapter provides the reader with a description of the methods utilized to obtain the information that was arranged and analyzed in order to assist the *Ecologia* in monitoring the pollution on Murano. This section also explains the ways in which the project team gathered and assembled the information while in Venice. The methodology chapter also discusses the reasons for undergoing such methods of research and the goals behind the research.

3.1. Project Objectives

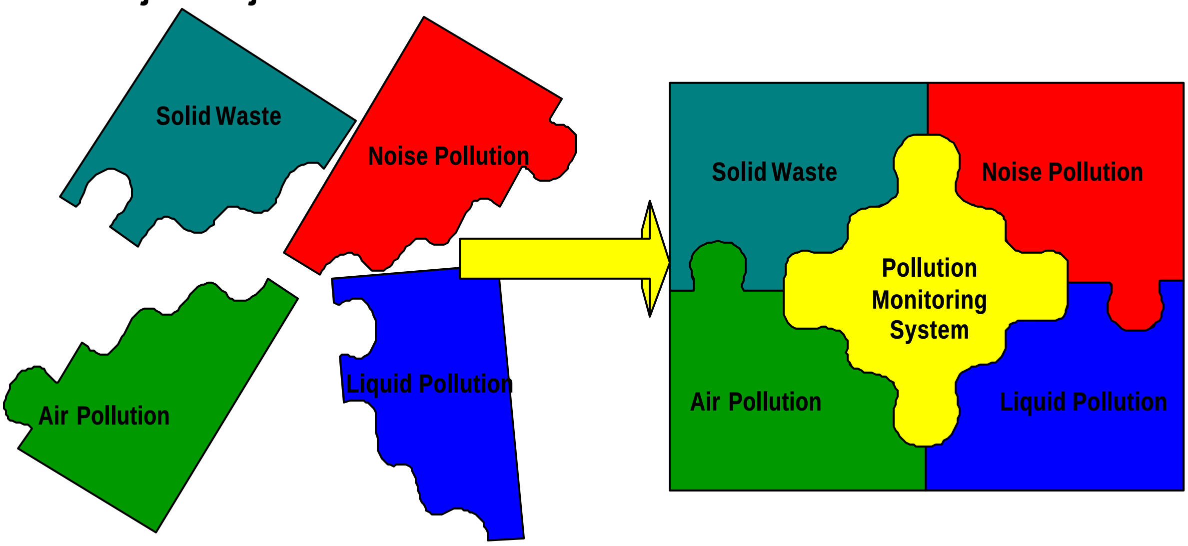

Figure 10 Piecing together pollution information

This study focuses on the manufacturing of artistic glass on the island of Murano in terms of the noise, air, and water pollution, as well as solid waste, created by this age-long trade. It is intended to aid the *Ecologia* in monitoring and reducing the environmental impact of pollution resulting from glass manufacturing while making it possible for the ancient tradition of glassmaking to continue. This was accomplished through the development of a pollution monitoring system for the management, control, and future modeling of pollution on the island of Murano. Figure 10 is a visual representation of what the pollution monitoring system accomplishes. The system brings together information on different types of environmental threats to form a complete picture of pollution on the island of Murano. Further analysis of the current glass production techniques and pollution data on Murano resulted in the proposal of modern pollution abatement solutions suited for the fragile socio-economic fabric and tradition of the island (see section 5.3-5.5). This will be useful to the glass manufacturers in meeting the regulations postponed by the *Accordo sul Vetro*. The results of this work will be the foundation for future environmental monitoring for other industries in the city of Venice.

3.2. Information Sources

In order to develop the pollution monitoring system, we identified and mapped all sources of pollution created by the manufacturing of glass by combining and analyzing data from several different sources in possession of the *Ecologia*. The main information we acquired was the exact locations and names of all of the glass companies operating on the island of Murano in the summer of 2000. The *Ecologia* provided us with a 1999 Chamber of Commerce list of glass manufacturers and a 1997 survey conducted by Coses of industries on Murano, called the *Piano Regolatore Generale Variante per l'isola di Murano*. Coses is a Venetian statistical firm that periodically conducts studies of industries. The survey of Murano was conducted in 1997 and includes basic company information, such as name, address, and number of employees. In addition, the survey includes other characteristics, such as whether or not the company can be accessed by water and how much space the company's facilities occupy. The forms were not completely filled out for most companies, so it was of little use for more than providing the name and address. A map showing the locations of all the glass manufacturers corresponding to the survey was also provided. Since businesses in the glassmaking industry of Murano change their name and address frequently, we checked and updated the data. The data we collected includes, but is not limited to, the area of the occupied buildings, the address of the building, or portion thereof, used for making glass, and the name of the glass companies. Pictures were taken of the entranceways of each company. This provides a visual representation that assists the user in locating the building, because not all buildings on Murano are clearly numbered and many are difficult to find.

One other source of information is data from noise pollution monitoring. This data was collected between June 12 and August 11 by *Agenzia Regionale per la Prevenzione e la Protenzione Ambientale del Veneto* (ARPAV) for the *Ecologia*. Although this data collection was not completed during the allotted time for this project, we established a means for incorporating it into the system.

3.2.1. Difficulties in Information Acquisition

A major roadblock throughout the project was acquiring information from other government agencies. The information for our project was dispersed among various departments of the *Comune di Venezia,* the *Provincia*, Chamber of Commerce, and ARPAV. In most cases it took several days for our liaison to obtain information we needed. Often, when we received the information, it was inaccurate and incomplete. An example of this was the set of blueprints for companies with chimneys. Upon examination, we found that some of the companies no longer existed, the labels for chimneys no longer matched up with the data retrieved, and some of the blueprints were not labeled or were missing sections. Also, we later discovered that there were several more blueprints that were never given to us. As a result of these complications, it was difficult to gather all the data we desired. However, the system is in place and is easily updateable should the information become available.

3.3. Project Phases

This section of the report is dedicated to the procedures and scheduling of the project phases. The project took place in Venice, Italy from June 1, 2000 to July 31, 2000. Data obtained about the pollution sources was placed within a collective database created using Microsoft Access. We also created several maps using MapInfo and data between these maps and the database is easily exchangeable.

The initial phase was to collect company and building information. We searched for glass manufacturers on Murano with the aid of the Chamber of Commerce list and the survey performed by Coses. The information collected in the field was used for our first original table and map. The initially created database table is the foundation for all other tables.

The second phase was to setup a preliminary structure for the database. This gave us the basic form with which to start entering the data provided to us by the *Ecologia*.

The third phase consisted of entering the air pollution data. This data was provided by the *Provincia*, the provincial government, and contained information on the chimneys of the first sixteen companies authorized to have atmospheric emissions. This process involved a few steps. First, we located where on each structure the chimneys are and added these locations to a layer in our map. We located the chimneys on architectural renderings that were provided by the companies when they received authorization for their chimney, and matched them with the appropriate buildings. Second, once we knew where each chimney was, we associated it with its emissions data (see section 4.4 and Figure 17).

The fourth phase was to use the storage tank blueprints provided with the permits for the storage tanks to determine the internal structure of the buildings. This assisted us in locating where the sewer connections and liquid waste outlets were. This step was accomplished by creating a map and was done through digitizing the blueprints, reducing them to scale, and fitting them within the perimeter of the buildings. This gave us a more complete picture of the production facilities and their liquied effluent lines.

The fifth phase was to incorporate pollution levels found in the sediments in the canals of Murano. This data was collected by the *Ecologia* in 1995 and shows the concentrations of several key pollutants that could originate from the glass factories. This information was added to another map layer to create a visual representation of the amount of each pollutant in the waterways. In conjunction with the sewer data, it may be possible to trace pollution back to individual manufacturers.

Finally, the information collected on noise pollution was included in its own map layer. We have provided the starting point to continue entering this information into the system when the data collection process has been completed.

When all of the layers are combined together, they form a complete picture of pollution on Murano. This information will help the *Ecologia* lead the companies into compliance with the new Italian environmental regulations. The next sections in this chapter outline in more detail the procedures used to create the various tables and maps necessary for completion of our pollution monitoring system.

3.4. Identification of Companies

Before we could analyze and link any data, we needed to get a complete up to date picture of the glass manufacturers on Murano. An initial database was created to provide a combined list of the existing company information. This database was linked into MapInfo to provide a visual representation of the current status of the existing glass manufacturing companies located on Murano. The information contained within the initial database contains the name and address of the company as well as the building they are located in. This project phase was completed first to aid in the identification of companies on Murano.

3.4.1. Positive Identification of Companies

To correctly match each glass manufacturing company to an address, our team surveyed the island of Murano. Murano is essentially a small group of islands that are separated from each other by canals. Our team surveyed one island per day during the late morning and early afternoon on weekdays. Most of the businesses and furnaces were open at this time. Information was obtained by visiting each building listed on both the 1997 Coses survey and the 1999 Chamber of Commerce list. We used the map layer we created with the initial database, which contains a visual model that locates each building on a map of Murano, to aid in finding the locations and streets. Once we located the buildings of glass manufacturers not already on the map (such as those in the Chamber of Commerce survey), we drew their perimeters on the map. We also checked the addresses of companies on the Chamber of Commerce list. Upon visiting a glass manufacturing building, we would cross check the present company's name and address with our database that contained the information from the Chamber of Commerce and the original Coses study. If the address and name found differed from our database, the new information was recorded. This is done to ensure that each glass manufacturing company matches up with a building. In order to provide a useful picture of the pollution caused by each company on Murano, it is necessary to link the company to a specific building and not an address or name. Buildings that contained glass manufacturing companies that did not exist on the initial map layer were recorded for deletion. In addition to this, a picture of the entrance to each business was taken and added to a separate database. The pictures were taken at high resolution with a Kodak DC240 digital camera.

To obtain this data, we visited the island individually or in a group of two or three persons. We found that generally two people worked best to document everything. It was easiest for one person to work with the existing map and to record the new structures and the other person would crosscheck both lists and record the new or changed names and addresses. If it was not clear if the business was a glass manufacturer or if it was closed, we would ask local residents if they knew about a glass manufacturer which had the name and address listed in our data. Also, some of the manufacturers had moved to other locations and talking to the local residents was the best way to find this information and avoid any future confusion.

Once we had our starting list of all of the companies on Murano we compared it to the list of companies that signed the *Accordo sul Vetro*. The *Ecologia* provided us with copies of the form signed by each glass manufacturer who agreed to the terms of the accord. From these forms we compared the names and addresses to the ones we gathered. We also denoted in our database which companies signed the accord as well as the protocol number assigned to them by the *Comune di Venezia*.

3.4.2. ISTAT Codes

In addition to identifying all of the companies, we also took note of their ISTAT codes. These codes identify the classification of a company. However, when the manufacturers are assigned codes they are not always for the prominent activity. These codes are assigned by the Chamber of Commerce and tell what the primary activity of a company is. Sometimes the manufacturers like to classify themselves as sellers because that is how they view themselves, even though they produce glass. Several companies have several codes as a result. Therefore, we had to eliminate those codes from our database that do not pertain to the manufacturing of glass.

We decided that the ISTAT codes were important to include because they can be used to determine the primary activity of a manufacturer. As such it may be possible to develop relationships between companies of similar production types and the types of pollution they produce.

3.4.3. Creation of the Initial Database and Map layers

A new database was then created in Access that serves as the base for the pollution monitoring system. The structure for this database was developed in conjunction with the sponsor and our advisors so that it would be as flexible as possible for the current use as well as for any future uses. A table was created that contained all of the information about the companies. A second table was then created that contained the basic data about each of the buildings delineated in the map layer. The companies are linked to the buildings that they occupy. The database was then linked with the map containing the buildings on Murano. This was accomplished by assigning each building its own code. First, all of the buildings had to be renumbered since not all of the buildings existed in the current numbering scheme. We decided it was necessary to create a more universal code that contained more information. In addition the basic structures for the tables for noise, air, and water pollution data were created.

3.5. Coding Systems

This section will describe the systems we devised to code businesses, buildings, chimneys, sampling sites, and pollutants. It was important to develop a uniform system for all of these so that the data could be linked and interrelated. In addition, this will simplify future reference to buildings and information, as it will all be standardized. A description of all the codes used can be found in Appendix F.

3.5.1. Business Codes (CODICE_AZIENDA)

The business codes are used to refer to the entire business including the sales offices, galleries, and all manufacturing sites associated with each company. This also includes all of the different establishments that are differentiated by type of production.

The system we devised for coding these is based on simplicity. We decided to sort all of the companies in alphabetical order and then assigned numbers 1-155 straight down the line. Thus the code for the first company alphabetically would be 001. Companies that may start in the future would then be added on to the end of this list in the order that they began business.

3.5.2. Building Codes (CODICE_EDIFICIO)

The next step was to assign each building for each company its own code. While most manufacturers had only one building, others had multiple. Also, companies in other industries may have more than one building. In addition, most of the sample sites and equipment we are dealing with are associated with the permanent structure of the building and will not change as often as the businesses; as such it was necessary to have a second code.

The building code is comprised of the three-digit island code, preexisting for the entire lagoon, and a three-digit number based on the north-south location of the building on the island. In order to do this, we determined the coordinates of the center of each building and ordered them from north to south by island. For example code 203-002 refers to the second company from the northern most point on San Donato (island code 203).

In the future a new glass manufacturer or an existing one may occupy a building between those already coded. If this is the case the three digit number can be followed by a decimal and then another number. For example, if a manufacturer moved into a location between building 203-002 and 203-003 the new manufacturer would be 203-002.5. This would allow the input of more buildings between the new manufacturer the already existing ones.

3.5.3. Plant Codes (CODICE_STABILIMENTO)

The plant codes were devised to deal with a company that has different plants to produce different materials. In our work we did not encounter the need to differentiate between the business codes and the plant codes and as such all of the plant codes are the same as the business codes.

The plant codes are composed of a three letter descriptor VET (for *vetrerie*), followed by a dash and then the business code. Thus for the company with business code 001, their plant code would be VET-001. Should a future differentiation need to be made, we suggest following our code with a dash and then another three-digit number for the code of the plant. This would like VET-001-001 for the first of the plants.

3.5.4. Pollutant Codes (CODICE_INQUINANTI)

In order to simplify future data entry procedures we assigned each type of pollutant we encountered a code. This code identifies the pollutant, and inside the database, links to a table that describes the pollutant and its toxicological information.

The structure of the pollutant codes is again based on simplicity. For an elemental or simple molecular pollutant, such as mercury and hydrofluoric acid, the element's symbol or molecular formula from the periodic table is used; in this case Hg and HF would be the pollutant codes. If the pollutant comes in the form of multiple compounds (as is common with air pollutants), such as arsenic and its composites, the code is the chemical symbol for the element followed by a dash and then a capital C for compounds. Arsenic and its compounds would then be As-C. Some exceptions exist for classes of compounds such as volatile organic compounds (*composti organici volatili*). In these cases we used capital letters that represent it in some manner, such as VOC for volatile organic compounds. This coding system was used for both the air and sediment pollutants.

3.5.5. Chimney Codes (CODICE_CAMINI)

In order to link the authorized air emissions, and in the future to link the actual air emissions, it was necessary to be able to uniquely identify each chimney. In order to do this, we decided to code each individual chimney. These codes allowed us to set the attributes for each chimney and to link pollution information.

In order to provide some information in the code as well as an identifier, we used the building code, to which the chimney is attached, followed by a dash and then the chimney number, which was found on the architectural drawings. For example chimney code 203-002-001 would refer to chimney number one on the second most northern company on San Donato.

3.5.6. Settling Tank Codes (CODICE_FOSSE)

We decided that it would be a good idea to code all of the existing settling tanks as well. Though there is no existing data for these as of yet, it might be acquired in the future. If so, the settling tanks will already have codes and entering the data will be easier.

Since the septic tanks were not numbered on the blueprints we developed a system where we coded them with the lowest number being closest to the outlet point for the system. The code is composed of the building code followed by a dash, then F for *fossa settica* (settling tank), or C for *condensagrassa* (grease settling tank), followed by its number. Thus if the last tank before the effluent point for building 205-002 was a *condensagrassa* its code would be 205-002-C01.

3.5.7. Drain Codes (CODICE_POZZETTI)

In addition to coding all the settling tanks, we coded the drains that lead to the piping connecting to the settling tanks. The drain codes are again based on the building codes. The drains were again coded in order from the point closest to the effluent stream to the farthest. In addition the classifications were distinguished by the letters A for *altro*, C for *colonna discarico*, and I for *ispezione*. Thus if the closest *pozzetto* to the effluent point in building 202-005 was an *ispezione* it's code would be 202-005-I01.

3.5.8. Furnace Codes (CODICE_FORNACE)

As with the settling tanks, we decided it would be a good idea to code all of the furnaces shown in our blueprints. These codes could be used in the future to link chimneys to the furnaces, or information from specific pollutants.

To code the furnaces we again used the same system as the chimneys. We followed the building code with a dash, then a letter and a two-digit number. The letter was based on what type of furnace; F for *fusione*, T for *tempera*, R for *riscaldamento*, and M for *muffola*. Thus the *fusione* furnace labeled one on the first building on Navagero would be 204-001-F01.

3.5.9. Interior Room Codes (CODICE_VANI)

We decided that it would also be useful to code the rooms that w e identified from the various sources of blueprints. This way if future information is obtained about what goes on in each room it would be easier to attribute the information. Again, the basis for these codes is the building code. Following the building code is a dash and then a letter for the type of room. The letters are: A for *altra*, M for *moleria*, F for *fornace*, D for *magazzino deposito*, C for *acidatura*, U for *ufficio,* and S for *sala*. The letter is followed by a two-digit number that is based on the room type within each building and its location form north to south inside of the building. Thus for building 202-005 the northernmost *ufficio* would be 202-005-U01. In the cases where the room was located on the second floor this code was then followed by a dash 1 to denote the second floor (in Italy the second floor is called the first floor, while the first floor is the ground floor).

3.6. Interior Rooms

When we initially examined the blueprints contained in the chimney authorizations and the settling tank authorizations we noticed that many of the blueprints also indicated the different types of rooms in each facility. We thought it would be important to document these as in the future data towards different production practices could be attributed to individual rooms and further pinpointing sources of pollution would be easier.

We divided the rooms into seven categories: *sala acidature* (acid baths), *fornaci* (furnaces), *magazzini deposito* (storage), *molerie* (grinding rooms), *uffici* (administrative offices), *sala esposizione* (show rooms), and *altro* (other). The *altro*, or other category, encompasses rooms that did not pertain to the production processes and were unimportant to business operations, such as bathrooms, or were not identified on the blueprints. These rooms were mapped and color-coded by type as well. We then assigned codes so future data can be attributed to them.

3.7. Air Pollution

In order to successfully measure air pollution caused by the glass manufacturing companies, one must take measurements from a specific output. The majority of the air pollution originates in the furnaces used by the glassmakers. Currently, most furnaces do not possess chimneys, they rely on the gases to just ventilate through openings in the roof so there is no method for obtaining accurate measurements as to how much each company is polluting. The *Provincia* provided us with authorized emissions data for the original sixteen companies that were given permits for chimneys. This data was sorted by company and by chimney and corresponded to the numbers on architectural drawings that were also provided to us by the *Provinicia*. Our team located each of the chimneys found in the sixteen companies and placed them within a map layer. The chimneys were located through the use of architectural renderings that were submitted by each company when applying for the chimney permits. By looking at the structures of the buildings in the architectural renderings it is obvious where the chimneys are located. The exact locations were then pinpointed in the buildings layer of our map. The blueprints also showed how each chimney was numbered according to the data gathered and provided by the *Provincia*. The levels of pollution emanating from each individual chimney is attached to a table within the database and linked into Mapinfo. The information on the chimneys was linked through the use of the chimney codes we developed. This allows the user of our system to identify the exact levels of air pollution caused by the company.

In addition to locating the chimneys, we also developed a layer of all the piping that connects each type of equipment to its chimney, a layer of the different pieces of equipment that use the chimneys, and a layer of the interior layouts of all the buildings for which we had blueprints. This was done by digitizing the blueprints and then scaling the prints to the size of our maps. We then registered the image by choosing three to four points where it corresponded with the map. We traced over the blueprint and created the layers described earlier. Since they came straight from the blueprints the layers are more accurate than had we drawn in the structures freehand. This gives a more complete picture of the operations and layout of each company.

3.8. Settling Tank Location

Another important piece of equipment that some manufacturers have is settling tanks. In order to install a settling tank, the manufacturer must file for a permit. Part of this application includes an architectural drawing showing the layout of the facility as well as the locations of the settling tanks. Though there is no current data on the effluent or the material inside of the septic tanks this could be acquired in the future. In order to do this, and determine if it is even beneficial to attempt it, the number of tanks and their locations must be known.

In order to locate the tanks we searched the blueprints provided with the permit applications. To create the layers necessary we followed a similar plan as for the chimneys. We digitized the blueprints and imported them into MapInfo. We then created several layers to show all of the information contained in the blueprints. These included layers for the settling tanks, pipes and joints, and inspection locations. This shows the interior layout of the plant as well as all of the pipes (dotted lines) and the location of the treatment areas (shown in pink). MapInfo can be used to calculate the total lengths of all the different types of pipes for each company, as well as the area occupied by the different manufacturing areas. Sewage lines are designated by dotted lines and there are different designations for different types of storage tanks and decontaminate tanks. Each room has been outlined with a color corresponding to its function.

3.9. Sediment Pollution

Pollution levels found in the sediments in the canals of Murano were incorporated into their own table in the database and linked with a map. This data was collected by the *Ecologia* in 1995 and shows the concentrations of several key pollutants that could originate from the glass factories. This information will be added to another map layer to create a visual representation of the amount of each pollutant in the waterways.

The original files of data no longer existed and it was only available in a book provided to us by the *Ecologia*. We then reentered all of the pollution values into the sediment pollution table in our database. Once this was complete, we reviewed the data to make sure all of our numbers matched those in the book. We then linked this section of the database to our map.

To link the data we used the existing codes for the sample sites in the book provided by the *Ecologia*. The superior and inferior strata were identified with an S or an I after the sample site number. Once the data was linked, we produced thematic maps showing the quality of the sediments.

3.10. Noise Pollution

Currently ARPAV, working for the *Ecologia,* has set up twenty three outdoor recording stations to monitor the levels of noise caused by the production of glass. The tests run from June 12, 2000 to August 11, 2000. During the months of June and July, the busiest season for glass production, the twenty three sampling stations are monitored for forty eight hours each. In the month of August, when production is halted due to the heat, the twenty three stations are monitored for what is called a blank value. The blank value is considered the normal sound level and serves as the base from which the peak values are compared.

We traveled with ARPAV to install the sound monitoring units. While there, we took pictures of each microphone installation for the records of the *Ecologia*. The microphones do not actually record the sound but instead are sound pressure level (SPL) meters. These record the amount of pressure of the peak sounds in decibels (dB). The units recorded data continuously for the forty eight hours. Each Monday morning three units were placed in locations near manufacturers. The positions were chosen in such a way that the noise could be attributed to an individual manufacturer. This was done through the specifications of the microphones, and also the way in which the microphones were placed. On Wednesday morning the units are retrieved, the data is downloaded, and then the microphones were setup in the next three locations. On Friday morning the units are taken down, the data is retrieved, and the units recharged for the weekend.

After the data was downloaded from the sampling units, it was returned to ARPAV for their analysis. We received the first sets of data in the middle of July. While waiting for the data, our first task was to pinpoint exactly where the microphones were attached on each building. We then entered the noise level data into our database using the *Ecologia's* sample site number as a site code and then linked this into our map and compared it to the legal levels allowed at each location.

3.11. Solid Waste

This project was not concerned with solid waste and the pollution caused by it. This is because, for the most part, the solid waste produced by the artistic glass industry is handled by outside contractors who pickup the waste and remove it to other locations. Besides, the *Accordo sul Vetro* does not have any regulations pertaining to solid waste, and the Ecologia is not presently concerned with studying this information.

3.12. Population Density

While compiling all of the information on pollution and glass manufacturing companies, we decided we needed a way to relate the information to how it might impact the island and its residents. We decided to solve this by creating a population density map.

The data for the map was obtained from a 1999 population survey. It came in the form of a text file, which we reorganized the data into a spreadsheet and sorted out the pertinent data on Murano. We then linked the population figures for Murano to the map layer for addresses. To provide a visual representation of the habitation of the island, we created a density map that averaged number of people in the same vicinity. These aggregates were then assigned a color based upon the number of people. This map can be combined with the other layers of our pollution monitoring system to show how pollution levels affects the population of Murano.

3.13. Development of Pollution Monitoring System

Individually, each of the sections of information described above do not provide much information, together they provide a great deal of information about Murano. Once we finished the development of each of the individual pieces, we combined them to form the pollution monitoring system. Each of the database tables we created were combined into one database and linked together to make it easier to update. All of the map layers we created were combined together to display as much information about Murano as possible. The map layers and database were then linked together so that data can be entered and analyzed graphically through the maps, or textually through the database. This provides plenty of options for the users of the database.

3.13.1. *Database Tables and Fields*

Figure 11 is shows the relationships between the tables in the database. All the pollution data, except the sedimentary data, is linked to the building code (CODICE_EDIFICIO) in the building

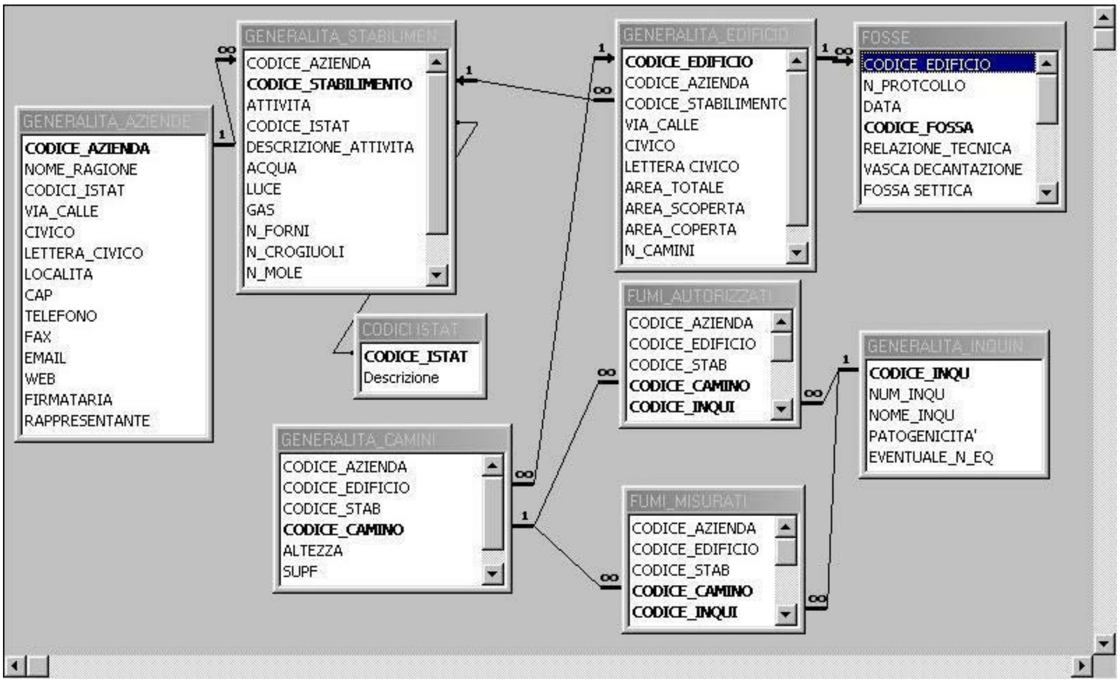

Figure 11 Relationships between codes and tables in the pollution monitoring system

information table (GENERALITA_EDIFICIO). This table consists mostly of physical data about the facility. This includes information such as total building area (AREA_TOTALE) and the number of chimneys (N_CAMINI). Information about the actual company is contained in two other tables. The GENERALITA_AZIENDE table lists the company's business information, such as mailing address (VIA_CALLE, CIVICO, and CIVICO_LETTRE) and telephone number (TELEFONO). Another table contains information about the company's production capabilities. For example, data about the number of furnaces (N_FORNI) and whether or not the manufacturer uses city gas (GAS) is located in this table. The complete database structure and format can be found in Appendix G in Italian and Appendix H in English.

3.13.2. *Map Layers and Descriptions*

The graphical portion of the pollution monitoring system is composed of sixteen layers. The following list tells the name of each layer and describes the type of information that can be found in the layer.

- Vetrerie 2000 – This layer contains the physical locations of all of the buildings we found to have glass manufacturers. The information on address, legal name, building code, business code, area, telephone, fax, and email is provided here. This is the base layer for the rest of the pollution monitoring system for Murano.

- Fanghi – This layer contains the locations of all of the sampling sites for sediment data from the upper strata (superiore). These are labeled by site code. In addition the levels of each of the pollutants are stored in the layer as well under their pollutant codes.
- Fanghi Inferiore – This layer contains the locations of all of the sampling sites for sediment data from the lower strata (inferiore). These are labeled by site code. In addition the levels of each of the pollutants are stored in the layer as well under their pollutant codes.
- Camini – This layer contains the physical locations of all of the chimneys, their codes, building codes, and authorized emissions for each pollutant in terms of kilograms per year. This table is what the real emissions data will be compared against.
- Fornace – This layer contains the physical locations of the furnaces as shown on the blueprints. In addition each furnace is coded and labeled by type.
- Trattamento Emissioni Aeree – This layer contains the locations of all of the treatment systems used for treating air emissions. Though these are not coded this layer can be updated in the future with system types, and efficiency information.
- Connettori Camini – This layer contains the piping that connects the chimneys to various pieces of equipment, and to the treatment equipment.
- Edifici Rumore – This layer contains the locations of all of the buildings used to monitor the noise levels. It has information on the address, the owners, and the days that the sampling was conducted.
- Vani Vetrerie Murano – This layer contains the regions of interior rooms for all of the buildings where we had blueprints. The rooms are classified by type and are each shown in a different color.
- Fosse Settiche – This layer shows the locations of each of this kind of settling tank. It contains the codes we issued the tanks, as well as the types. In addition there is room for dimensions of the tank.
- Pozzetti – This layer contains information on the drains and pipe joints. Inspectable areas are denoted by a different textured region.
- Scarichi Fognatura– This layer contains the locations of all of the pipes that lead form the manufacturers to the canals or the lagoon. These are the main outlet points of the wastewater.
- Scarichi Fognari Ipotizzabili – This layer contains information on our hypothesized locations of sewage pipes of the manufacturer that either empty into the canals or lagoons, or head to a communal collector.
- Scarichi – This layer contains the piping inside of the manufacturing plants. These pipes include those from machinery to drains, and to septic tanks.
- Densità di Popolazione – This layer contains the grid for the population density map of Murano.

- Civici Murano – This layer contains the data used to construct the population density map.

Together, all of these layers and the database combine to form our pollution monitoring system. This system has the potential to be very beneficial in aiding the *Settore Sicurezza del Territorio* in monitoring pollution on Murano. However, in order to be completely effective more data must be gathered and input into the system, specifically on water pollution, and actual emissions form chimneys. In addition the system must be continually updated and maintained.

3.14. Presentation of Results

When all of the data was compiled into the various thematic maps and the database, we presented it to the *Ecologia* in a paper and as computer files. The graphical and informational database provides a complete picture of the pollution on Murano. The system is made of sixteene original map layers that tie together data collected in the field. We explained how the *Ecologia* could expand upon our work so it is useful for their plans for environmental monitoring. The pollution monitoring system will be easy to alter for future updates on any and all data.

4. RESULTS AND ANALYSIS

This chapter discusses the results obtained from the information collected on the glass manufacturing companies, canal sediments, air emissions, and noise monitoring on the island of Murano. In addition we have provided our interpretations of these results.

4.1. Positive Identification of Companies

The island of Murano is approximately 1.8 sq. km. We identified 155 glass manufacturing companies occupying 172 buildings on Murano. The glass manufacturers occupy approximately 13% of

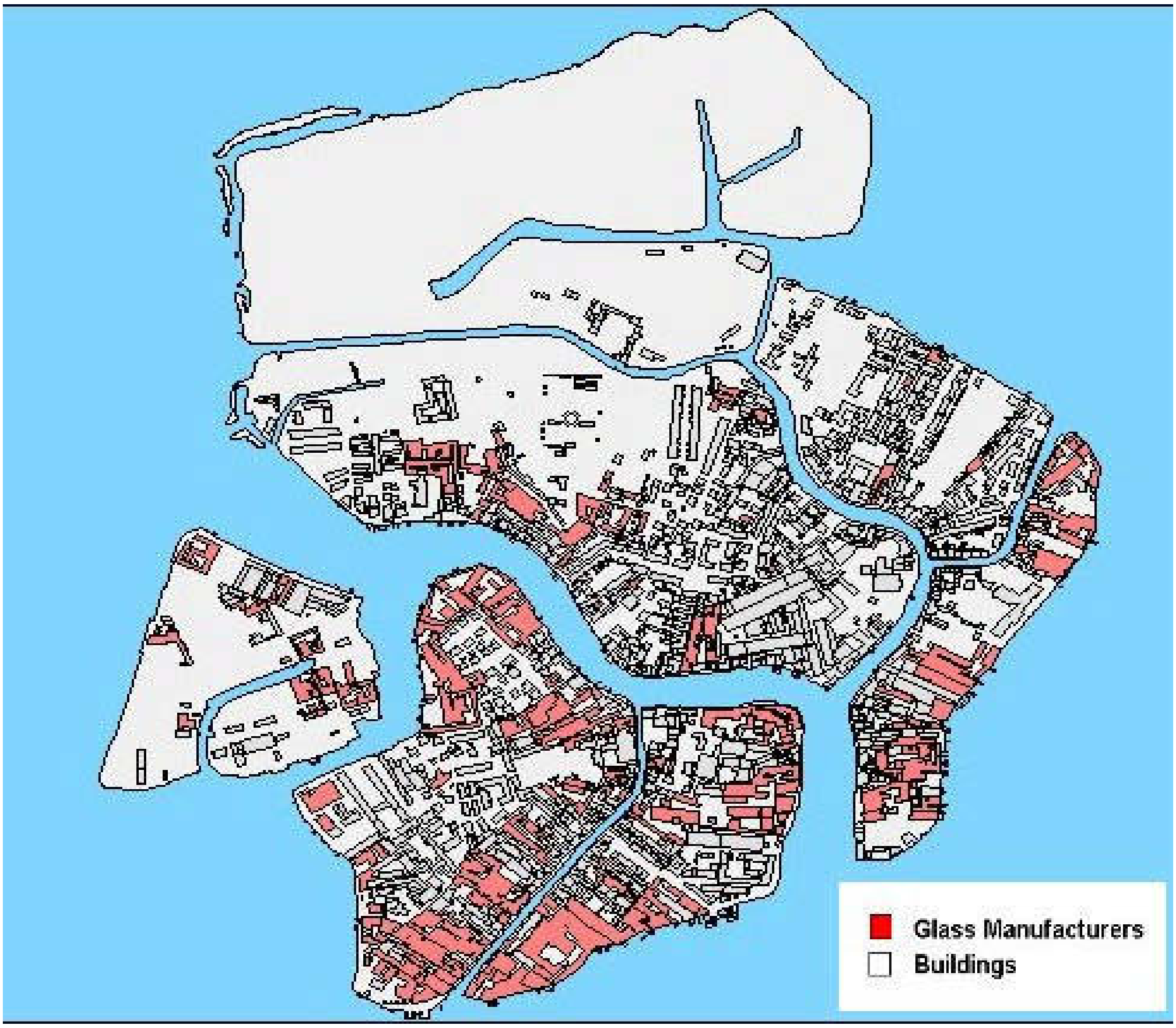

Figure 12 Buildings occupied by the glass manufacturers of Murano

the area of the island. Figure 12 gives an overview of the completed building layer of our map. Solid red regions indicate the buildings occupied by the 155 glass manufacturers. We recorded the address of each complex of buildings involved in the production of glass and the names of the companies currently operating in each facility. We discovered that several of the businesses have changed names and locations since the data in our initial database was recorded. A complete list of the companies and their addresses can be found in Appendix L. After gathering the information from this field research, we compiled an updated database of the glass manufacturing companies on Murano, complete with their address and building location. This information was stored in the GENERALITA_AZIENDE table of our database. Also, a form was created that contains information on the company as well as a photograph of their entranceway and a detailed map of the buildings operated by the company. The form acts as a way to catalog the glass manufacturing companies on Murano. A complete catalog of companies was printed and presented to the *Comune di Venezia* for their records.

4.1.1. Accord Signers & Aziende a Norma

Currently, 70 companies have signed onto the Glass Accord. A map was created indicating the

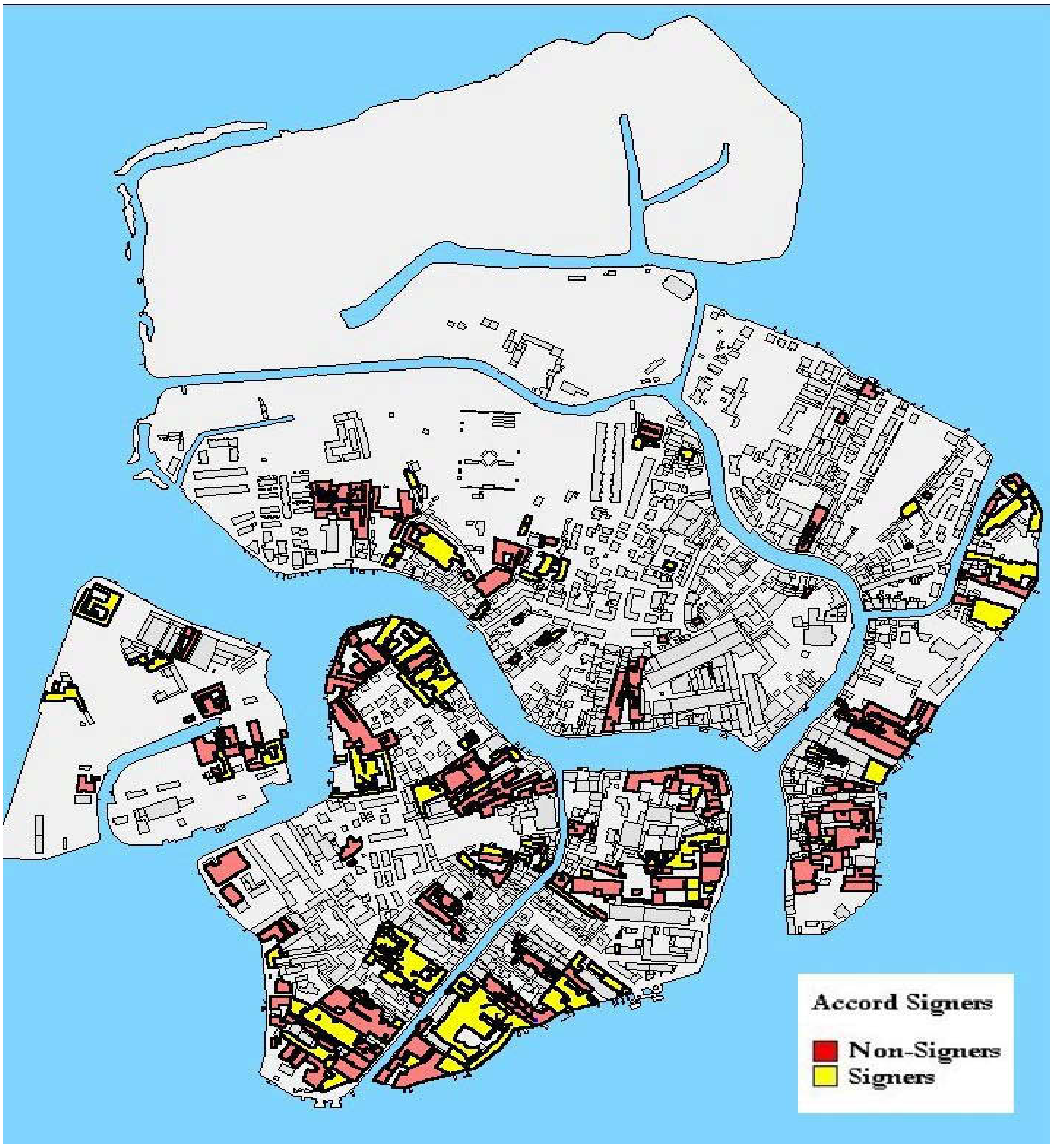

Figure 13 Companies that have signed the accord

companies that signed on to the accord. These companies are shown in yellow on the map in Figure 13. Approximately half of all the glass manufacturers identified signed the accord and it is unknown why so few did. The companies who did not sign (shown in red) must meet the regulations that are already in place, effective immediately. It is believed some companies are already in compliance, but others may have misunderstood the accord and mistakenly believe they are in compliance. Our project team composed a list of companies with their addresses that was turned over to investigators who will determine if individual companies are in compliance with current regulations.

4.1.2. ISTAT Code

As stated in the methodology chapter, these codes provide an indication of the type of activity a company performs. We thought it was important to be able to classify the manufacturers by their ISTAT code in case a future relationship based on type of glass produced and industrial activities could be linked to types and levels of pollutants. We found our ISTAT codes in three different locations: the accord forms signed by companies, on the chamber of commerce list, and from the Coses survey. Figure 14 shows the distribution of the major ISTAT codes we encountered in the glass manufacturers of Murano. Unfortunately, it turned out that some of the codes (all codes beginning with 24) from the Coses survey were obsolete and had been replaced. We were unable to obtain the new codes from the Chamber of Commerce during the time frame of the project. It is believed, however, that the codes beginning with 24 now begin with 26. If this is the case, then 90% of the glass manufacturers on Murano would be classified as 26. This means that they are an industry involved in the production of glass and products made from glass. A complete list of all of the ISTAT codes we encountered, their description, and the number of each can be found in Appendix E.

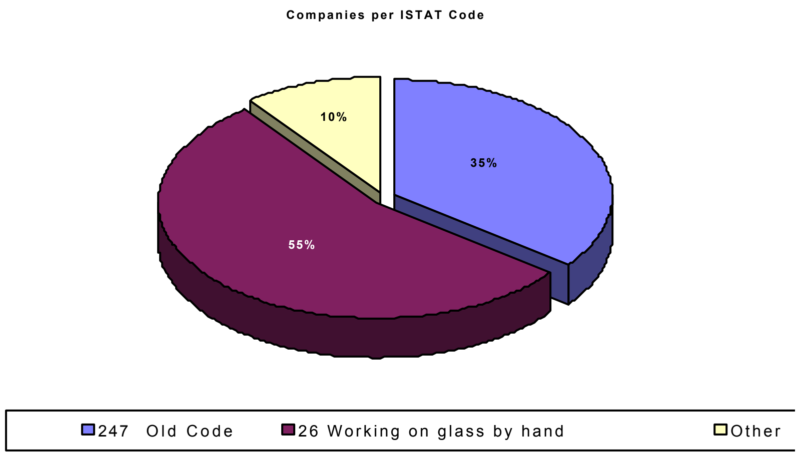

Figure 14 Distribution of ISTAT codes

4.2. Population Density

To aid in future pollution modeling and to ascertain how Murano's population is affected by pollution, we created a population density map based on the 1999 population of Murano. For example, this map can be used with noise data to help determine where noise pollution will affect local residents the most. The map can be used with air pollution data as well to show possible health risks for residents. Figure 15 shows the population density of Murano and the locations of the glass manufacturers.[52] The red and orange areas are the areas of highest population, yellow to green colors show the middle ranges, while the dark blue regions are of the lowest population. As can be seen, there are a few locations where high concentrations of people and glass manufacturers are in the same area. The areas where high population density and high concentration of glass manufacturers occupy the same space could be a reason for many of the complaints received by authorities. However, in most places the population is apparently staying away from the glass manufacturers. This is most noticeable on San Stefano where there is a high concentration of glass manufacturers, and a low concentration of people.

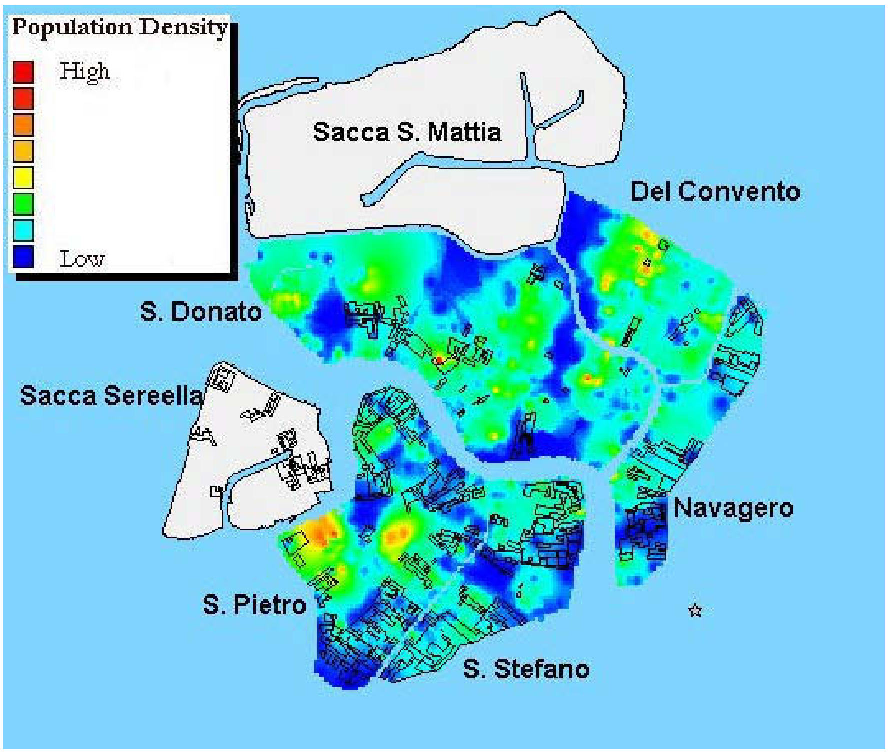

Figure 15 Population density and glass manufacturers

4.3. Interior Rooms

The blueprints for the septic tank and chimney authorizations allowed us to create several maps that display the interior structure of the glass manufacturers. The map named *Vani Vetrerie Murano* outlines the different rooms of a building by a color corresponding to its use. In this map, there are 523 rooms dispersed among 51 buildings. A majority of the rooms (53.2%) are labeled *altro,* or other, because they did not fall within our definitions for the other six types of rooms (*fornaci*, *molere*, *magazzini*, *sala acidatura*, *uffici*,, or *sala espozione*) or their use was not detailed within the blueprint. The 278 rooms categorized as *altro* also occupied the most area within the map.

The total area for the *altro* is 26509 square meters, accounting for 43.6% of the area for all of the rooms. While there was only 31 *fornaci*, or rooms with furnaces, which make up 5.9% of the rooms, they accounted for 26.6% of the total area for all rooms in the map with an average area of 521 square meters. Through examination of the blueprints, it was discovered that for most manufacturers the *fornaci* were the largest rooms. This is logical, because the *fornaci* is where the glass is actually produced. A summary of the information, concerning the interior rooms of companies, obtained from the authorization blueprints is shown in Table 7.

Table 7 Summary of interior rooms data

Room	Number	Average Area (sq. m)	Sum of Areas (sq. m)	Percent of Total Area for All Rooms
Fornaci	31	521.2	16158.3	26.6
Molerie	43	103.5	4448.8	7.3
Magazzini	109	93.5	10113.4	16.6
Sala Acidatora	2	74.5	149.0	0.2
Uffici	56	57.5	3221.4	5.3
Sala Espozione	3	49.8	149.4	0.2
Altro	278	95.4	26509.0	43.6

4.4. Air Pollution

We received copies of chimney authorizations for sixteen companies, which accounted for a total of 106 chimneys. Companies have anywhere from one to sixteen chimneys. The chimneys are attached to different pieces of equipment, from furnaces to grinding machines. In the companies we studied, there are a total of 36 treatment devices attached to the chimneys (34%). However, some of these treatment devices only treat individual pollutants, such as cerium, which is used in some of the grinding media.

[52] The islands of Sacca San Mattia and Sacca Serenella have been left off since there was no population data for these areas.

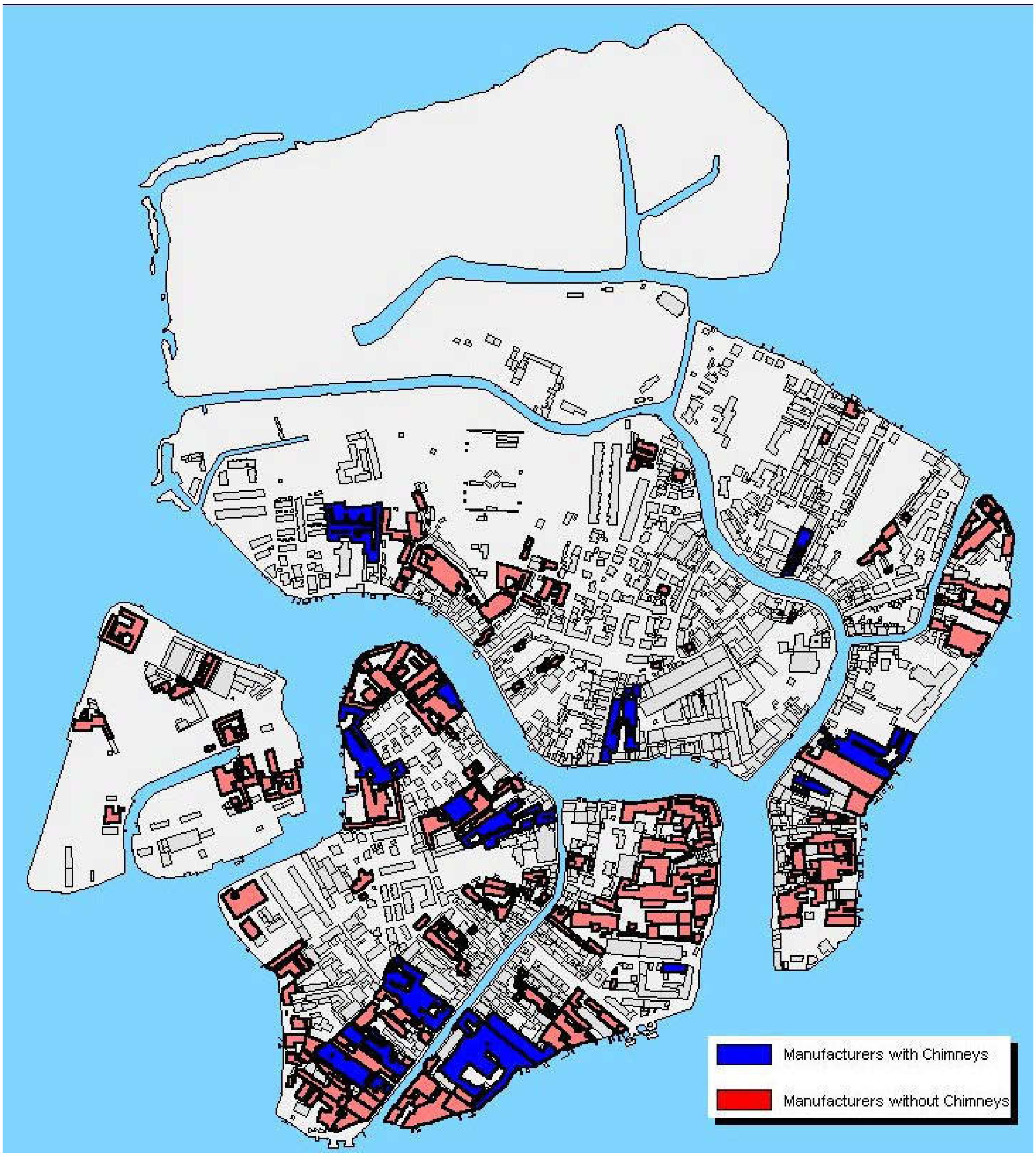

Figure 16 Sixteen companies with chimney authorizations

The sixteen companies containing chimneys are shown in blue in Figure 16. Towards the end of the project we received word that there are now twenty two companies authorized for emissions from chimneys. However, we only received data on the first sixteen. Since every company that signed the accord will be required to install a chimney there will be many more authorizations that will be submitted toe the *Comune di Venezia*. This new data will have to be added to our system when it becomes available.

Figure 17 shows a company with chimneys. The blue circles on the map indicate chimney locations. The black lines show the path of piping connecting the chimneys to different pieces of equipment. The dark green regions represent the different furnaces that the chimneys are attached to. These were also taken from the blueprints submitted to the *Comune di Venezia* as part of the authorization

Figure 17 Chimney locations within building

process. The yellow shapes represent stations for removing certain pollutants from the chimney emissions. The data for the levels of emissions for each chimney are contained in a database associated with the chimney map. The user is therefore able to obtain information specific to each chimney within the company by clicking on the map.

Unfortunately, we were unable to obtain information about the levels of emissions actually released through the chimneys. However, when this information becomes available the system is able to graphically show the amount of emissions from each individual chimney. The only information we were able to collect at this stage was the legal limit of emissions capable of passing through each chimney. From this we can draw conclusions as to the maximum amount of pollution capable of being produced without infringing the authorization. This could serve as a model of a worst case scenario for the air pollution caused by the authorized emissions released by the glass manufacturing companies.

4.5. Estimation of Maximum Authorized Emissions

To aid in the future monitoring of air pollution we decided to develop a worst case scenario based on authorized chimney emissions. The chimney authorizations we received showed data in terms of the amount in kilograms per year of various pollutants that each chimney a company had was authorized to emit. We totaled the kilograms per year of each type of pollutant by company, and then by pollutant. This gave us the total kilograms authorized to be emitted per year for our sixteen companies. We then converted this value to metric tons per year. Currently, there is no estimation as to the total amount of air pollution produced annually on Murano. In order to gain an idea of the amount of pollution on Murano we decided to extrapolate for a worst case scenario: each company produced the maximum allowable pollutants. We extrapolated the data from our sixteen examined companies to the entire island. This was

Table 8 Estimation of total pollutants per year (based on authorizations)

NOME_INQU (Pollutant)	Total Of kg per year authorized	Tons per year author.	Estimated Tons Total per year (based on No. Crogiolo)	Estimated Tons Total per year based on (No. Vasche)	Average tons per year
Antimonio (Antimony)	274.40	0.27	0.65	0.63	0.64
Bario (Barium)	40.96	0.04	0.10	0.09	0.10
Calcio (Calcium)	1045.44	1.05	2.47	2.41	2.44
Cerio (Cerium)	3.93	0.00	0.01	0.01	0.01
Cobalto e i suoi composti (Cobalt compounds)	272.93	0.27	0.64	0.63	0.64
Composti del cadmio (Cadmium compounds)	185.62	0.19	0.44	0.43	0.43
Composti del cromo (Chromium compounds)	147.08	0.15	0.35	0.34	0.34
Composti dell'Arsenico (Arsenic compounds)	292.29	0.29	0.69	0.67	0.68
Composti organici volatili (Volatile Organic Compounds)	106.32	0.11	0.25	0.25	0.25
Fluoro e fluoruri (Flourines like HF)	2462.32	2.46	5.81	5.68	5.75
Manganese	303.73	0.30	0.72	0.70	0.71
Monossido di carbonio (Carbon monoxide)	237.60	0.24	0.56	0.55	0.55
Neodimio (Neodynium)	1.14	0.00	0.00	0.00	0.00
Nichel (Nickel)	247.59	0.25	0.58	0.57	0.58
Ossidi di azoto (nitrous oxides)	1139618.59	1139.62	2690.77	2629.89	2660.33
Ossidi di zolfo (Sulfurous oxides)	29184.00	29.18	68.91	67.35	68.13
Particelle sospese totali (Particulates)	20309.75	20.31	47.95	46.87	47.41
Piombo (Lead)	696.11	0.70	1.64	1.61	1.62
Rame (Copper)	275.11	0.28	0.65	0.63	0.64
Selenio e i suoi composti (Selenium composites)	274.62	0.27	0.65	0.63	0.64
Silice Cristallina (Cristalline silica)	295.49	0.30	0.70	0.68	0.69
Stagno (Tin)	65.13	0.07	0.15	0.15	0.15

done by a percentage of total furnaces and the results are shown in Table 8. The glass accord details that there are 340 *forance a crogiolo* (melting furnaces) and 60 *fornace a vasca* (day furnaces). These are two different kinds of furnaces that are used in the production of glass and were differentiated in the blueprints. The production values for the accord (approximately 13,000 tons of glass per year) were based off of this data. We counted the number of furnaces for our sixteen companies, which were indicated on the blueprints filed for chimney authorizations. We assumed that this ratio was approximately the same as the ratio of the total production of glass of our companies, compared to the total production of the island. This ratio would then be the same for the ratio of pollutants emitted by our companies as compared to those emitted by all companies. Using this ratio, we extrapolated the maximum authorized tons produced per year of each pollutant for all glass manufacturers. Since we had data for both different types of furnaces, we computed both ratios and averaged them to get an average amount of tons authorized produced per year (see both estimated tons columns and average estimated tons column).

While extrapolating by the number of furnaces may be less accurate than doing so by tons of glass produced per year (which is also noted in the accord), we did not have this data for our sixteen companies. If this data were to be acquired, it could easily be used to make additional extrapolations that are more likely to be accurate. In addition, if the values on the accord rise because the amount of glass produced rises, our data can not be extrapolated to accommodate this new data, as the number of furnaces may not necessarily increase.

4.6. Estimated Maximum Authorized Emissions and the Glass Accord

After determining the estimated maximum authorized levels, we decided to compare these to the values the Glass Accord hopes to achieve. While examining the emissions from the authorized chimneys, we noticed that the current authorized concentrations were equal to the concentrations that the accord wished to achieve. We compared our estimated totals from the maximum of current authorizations to the total tons of pollutant per year the accord hopes to achieve. Table 9 shows the data chart we

Table 9 Calculated authorized concentrations

NOME_INQU	Accord Tons per year	Tons per year auth.	% accord value	reduce by tons	reduction ratio	Accord Concentrations	New Suggested Auth. Concentration
Antimonio	0.53	0.64	1.21	0.11	0.17	0.50	0.41
Cobalto e i suoi composti	0.53	0.64	1.20	0.11	0.17	0.50	0.42
Composti del cadmio	0.11	0.43	3.94	0.32	0.75	0.20	0.05
Composti del cromo	0.53	0.34	0.65	-0.19		0.50	0.50
Composti dell'Arsenico	0.53	0.68	1.29	0.15	0.22	0.50	0.39
Fluoro e fluoruri	4.20	5.75	1.37	1.55	0.27	4.00	2.92
Manganese	0.53	0.71	1.34	0.18	0.25	0.50	0.37
Nichel	0.53	0.58	1.09	0.05	0.08	0.50	0.46
Ossidi di azoto	870.00	2660.33	3.06	1790.33	0.67	1800.00	588.65
Particelle sospese totali	42.00	47.41	1.13	5.41	0.11	40.00	35.43
Piombo	0.53	1.62	3.07	1.09	0.67	0.50	0.16
Rame	0.53	0.64	1.21	0.11	0.17	0.50	0.41
Selenio e i suoi composti	0.53	0.64	1.21	0.11	0.17	0.50	0.41
Stagno	0.53	0.15	0.29	-0.38		0.50	0.50

produced. For the analysis of the air pollutants, there are fewer pollutants than Table 8 since it contains only those regulated by the accord. This chart can be used to follow our calculations. The comparison was accomplished by subtracting the tons per year the accord wishes to achieve (Accord tons per year) from our estimated authorized tons per year (Tons per year authorized). This value (reduce by tons) is the amount that the estimated total must be reduced by in order to meet the accord. We then divided this value by our estimated total production per year in order to get a ratio that the pollutants need to be further reduced by. Finally, we multiplied (1-ratio) by the concentrations in the accord to get a concentration that would allow the maximum authorized levels to meet the values established in the accord. Most of the current concentrations need to be reduced by a further twenty percent in order to meet the goals of the accord. Before performing this analysis, we thought the maximum chimney authorizations would keep emissions within regulation, but this is obviously not the case. Of course, if none of the companies reach their maximum authorized values, then the air pollution would be even less and could be in compliance with the law.

Since this analysis is based on the data from the estimated maximum authorizations, it is subject to the same error described before. However, this analysis provides a good starting point to support the goals of the accord and determine if current authorizations will allow the manufacturers to meet the overall goals.

When information is collected on the chimneys of all other companies, one will be able to monitor the levels of emissions produced by the glass manufacturers. This will provide a more accurate image of the air pollution caused by the glass manufacturing industry of Murano.

4.7. Septic Tanks and Wastewater Flow

The collection and treatment of wastewater in the glass manufacturers is accomplished through the use of *pozzetti* and *fosse*. *Pozzetti* are drains and collecting device, while fosse are settling tanks which let the pollutants settle out before releasing the water to pipes into the lagoon or canals. We used the

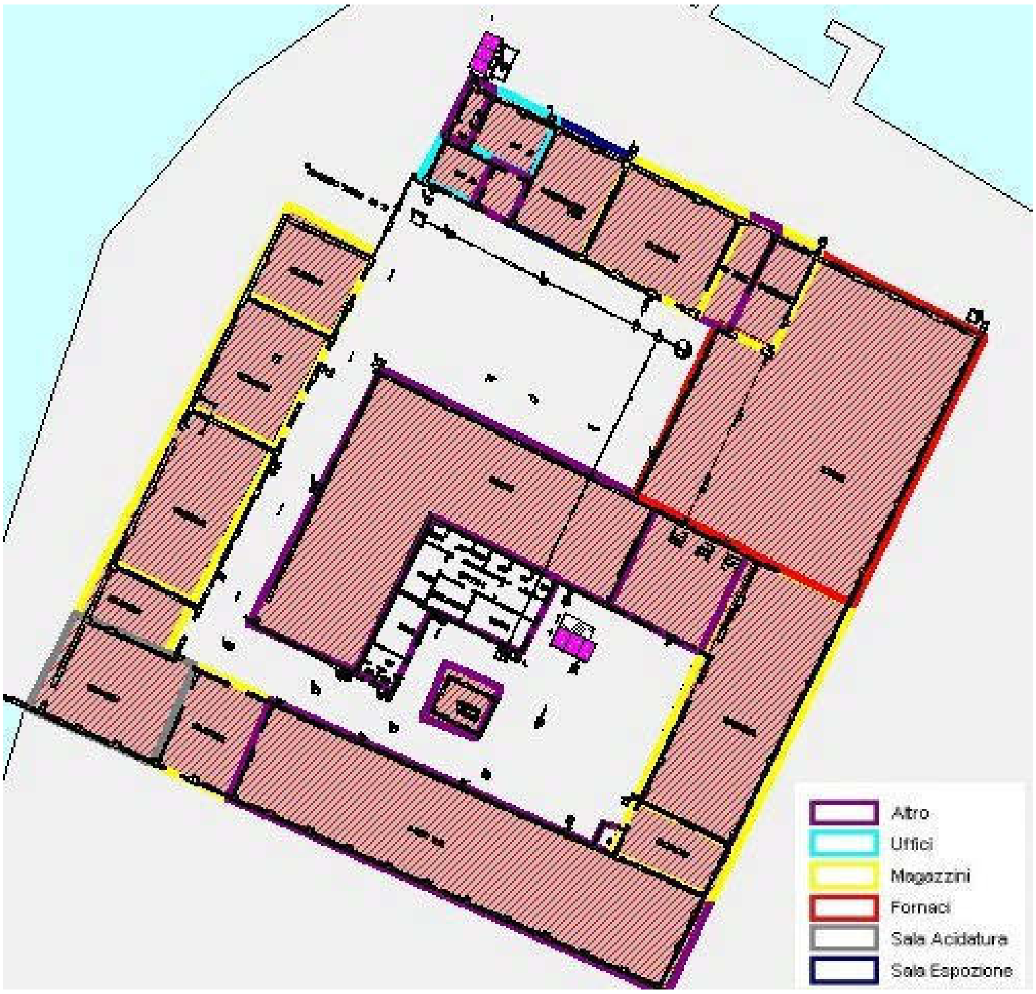

Figure 18 Composite map of sewage lines, storage tanks, and rooms

blueprints sent to the *Comune di Venezia* with the permit requests for the tanks. We created maps of the locations of each *fossa* and each *pozetto*. Of the thirty three buildings for which we had authorizations, all contained *pozzetti* (22% of all manufacturers) accounting for 401 total *pozzetti*, and twenty contained *fosse* (13% of all manufacturers) with a total of 61 *fosse*. We divided the *pozzetti* into three categories: *colonna di scarico* (drains at the joints of pipes), *pozzetti di ispezione* (inspectable drains), and *atlra* (other). The *altra* category contains all *pozzetti* not identified by type on the blueprints, and those types which were not inspectable. We divided the *fosse* into five categories: *biologica* (biological), *circolare* (circular), *condensagrasse* (grease settling tanks), *ispezionabile* (inspectable), and *non ispezionabile* (not inspectable). We found 305 *pozzetti* in the *altra* category, 54 *pozzetti* in the *colonna* di *scarico* category, and 42 *pozzetto di ispezione*. Of the fosse, there were two *biologica*, two *circolare*, ten *condensagrasse*, sixteen *ispezionabile*, and thirty one *non ispezionabile*. Once we identified the different drains and tanks, we also diagrammed the locations of all of the internal pipes, and the pipes used for the final effluent into the canals, or the lagoon. From the data entered in the map layers, we find that there are over 2,720 meters of internal wastewater pipes (*scarico*). Figure 18 is an example of a building with all of the pipelines, settling tanks, drains, and rooms filled in.

Using the locations of the effluent pipes provided on the blueprints, we hypothesized where each pipe outlets into the canals or lagoon. This is shown in Figure 19. Of the twenty pipes we found going

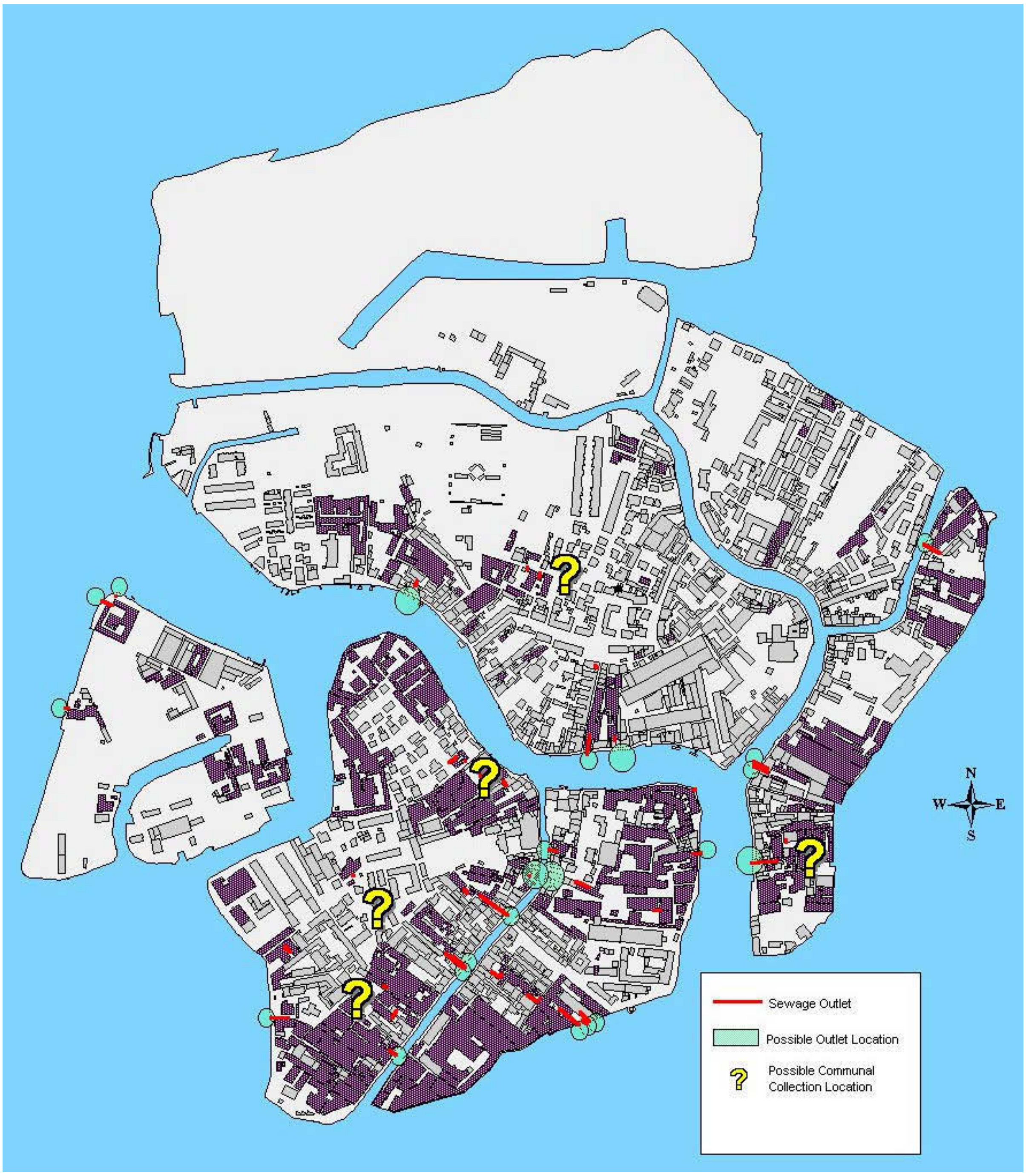

Figure 19 Sewage outlet lines and possible outlet locations

directly into public water, two empty into Canaillele San Donato, six into Canaille Grande, one into Canaille San Mateo, seven into Rio die Veteran, and six directly into the lagoon. The transparent circles show our estimation as to where the outlets of the pipes may be. These were determined by extending the lines to the edge of the islands. Twenty six of the outlet pipes did not head directly toward the waterways, but instead towards communal collectors, which then empty into the water. The question mark shows where we think community collectors may be. These were determined by extending some of the outlet pipes until they appeared to converge, or into an open area where the collector could be.

4.8. Pollution in Canal Sediments of Murano

In the 1995 survey of sediments of the canals of Murano, thirty seven points were sampled for sediment pollution. Of these, all of the sites had data for the upper sediment strata, while only seven had data for the lower strata. In most cases this is because the lower strata was either compact sediment that was too hard to sample, and has been shown to be devoid of pollutants, or was composed primarily of rock and pebbles which were unnecessary to sample. Of the thirty seven points sampled in the upper strata, six were class D sediments, the most polluted class. Twenty eight were class C sediments, and three were class B sediments. Of the seven points in the lower strata, one was class D, 4 were class C, and two were class B sediments. The levels of pollutants for each class can be found in Table 4.

Table 10 Levels of contaminants in sediment of canals (milligrams of pollutant per kilogram of dry sediment)

Statistics	Hg	Cd	Pb	As	Cr	Cu	Ni	Zn	Hydrocarbon	IPA	PCB	Pesticidi
Average	2.030	1.688	166.932	17.491	28.864	181.818	32.614	231.091	529.659	1.618	0.106	0.003
Standard Deviation	1.723	1.989	289.239	6.513	3.414	599.620	3.642	122.328	264.717	3.060	0.219	0.003

The levels of contaminants in the sediment at different points in the canals of Murano can be found in the sediment pollution table in the database. The statistics shown in Table 10 are average values based on the levels of pollutants for all sample sites, both upper and lower strata. Their chemical symbols or abbreviations identify the pollutants. The values are shown in milligrams per kilogram of dry sediment. These values can be used as generalities for milligrams of pollutant per kilogram of dry sediment. As shown by the standard deviations, which are larger than the average values, these may not prove good estimates. The averages are skewed by the presence of large concentrations of pollutants from the D class sediment levels.

In addition to finding the average values for the pollutants, we decided to see if there was a noticeable relationship between the pollution in the upper strata and that found in the lower strata. In order to determine this, we isolated the seven regions containing data for both points. The ratio of the

Table 11 Comparison of sediment strata

Sample Site Number	Hg	Cd	Pb	As	Cr	Cu	Ni	Zn	Tot HydrCar	IPA	PCB	Pesticidi
1	1.7143	1.3125	1.3154	0.9919	1.2667	1.4904	0.9697	1.3882	2.0820	1.0000	1.0000	1.5000
2	0.7143	0.5238	1.4444	0.5970	0.8750	0.8116	0.9697	0.6766	1.7976	1.5000	0.6250	1.0000
3	1.5714	1.6667	0.7326	0.9453	1.0385	1.5556	1.0303	1.5455	0.9118	1.0000	1.0000	3.0000
4	0.9444	0.1765	0.4639	0.7070	1.0370	1.0980	1.0000	0.8768	0.9608	1.2000	1.0000	1.5000
5	0.7391	0.9091	0.8108	0.9452	0.9286	1.2759	0.9722	1.0279	1.2361	1.0000	2.0000	1.0000
average	1.1367	0.9177	0.9534	0.8373	1.0291	1.2463	0.9884	1.1030	1.3976	1.1400	1.1250	1.6000

concentrations of pollutants of the upper layer was compared to the concentrations of pollutants in the lower layer. The extreme values (highest and lowest) of each pollutant were then dropped to create a more accurate picture. The ratios were then averaged over the five remaining sites to provide a ratio of pollutant in upper strata to pollutant in lower strata. The closer these ratios are to one, the more closely related the two layers of sediment are for that pollutant. As can be seen in Table 11, there is not a consistent difference between the upper and lower strata of sediments. This means that there is not a common relationship between sediment layers for any type of pollutant. However, the closer these ratios are to one, the more closely related the two strata are. Hence, generalizations about which layer is more polluted are difficult to make.

Following the entry of the sediment data into a table, we created map layers that correspond to this data. These maps show where each sediment sample was taken. Figure 20 shows the map layer and all of Murano. These maps, as well as the original data, were obtained from *Caratterizzazione e Classificazione*

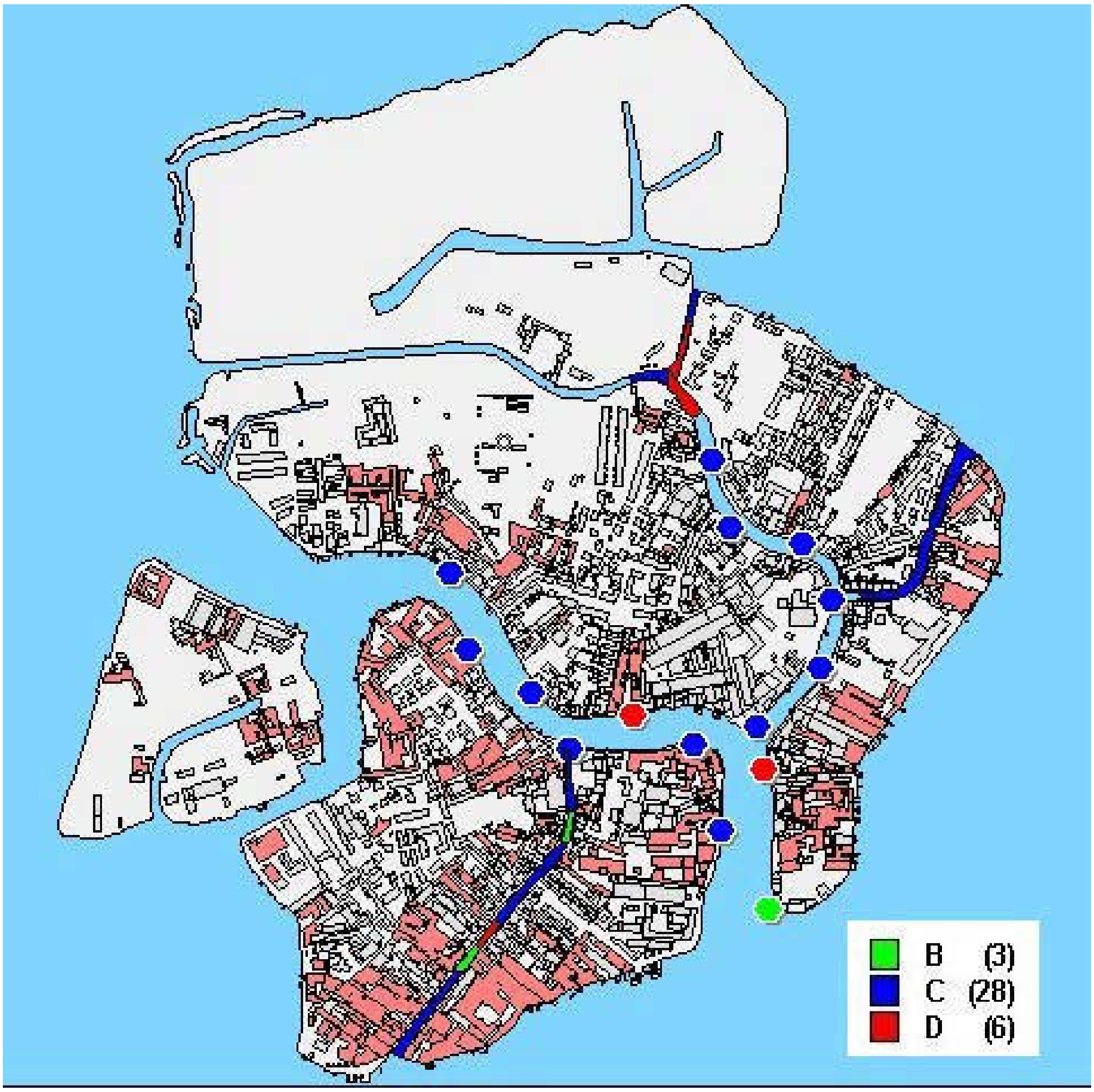

Figure 20 Sediment classes by sample site

dei Fanghi, a publication by the *Ecologia* containing data collected in February of 1995 from canal sediments in Murano, Burano, and Torcello. The original electronic copy of the data was unavailable, leaving the booklet as the only source for this information.

The colored regions of the canals indicate the classification of the sediment. The tested sediments were classified into four groups; A, B, C, and D. The level of contamination increases from A to D. Blue corresponds to class B, while green indicates class C sediment. Class D levels of contamination, the most polluted class, is indicated with red. The pollutants continuously build up in the sediment, therefore it is hard to attribute the pollution to any one individual company or group of companies for any specific frame of time. The levels of contaminants in the sediment are used to show the overall condition of the canals. Unfortunately, we do not have sufficient data to draw up an accurate representation of the whole canal system. In order for us to accomplish such a task it would be necessary to have measurements for several points throughout the whole canal structure of Murano.

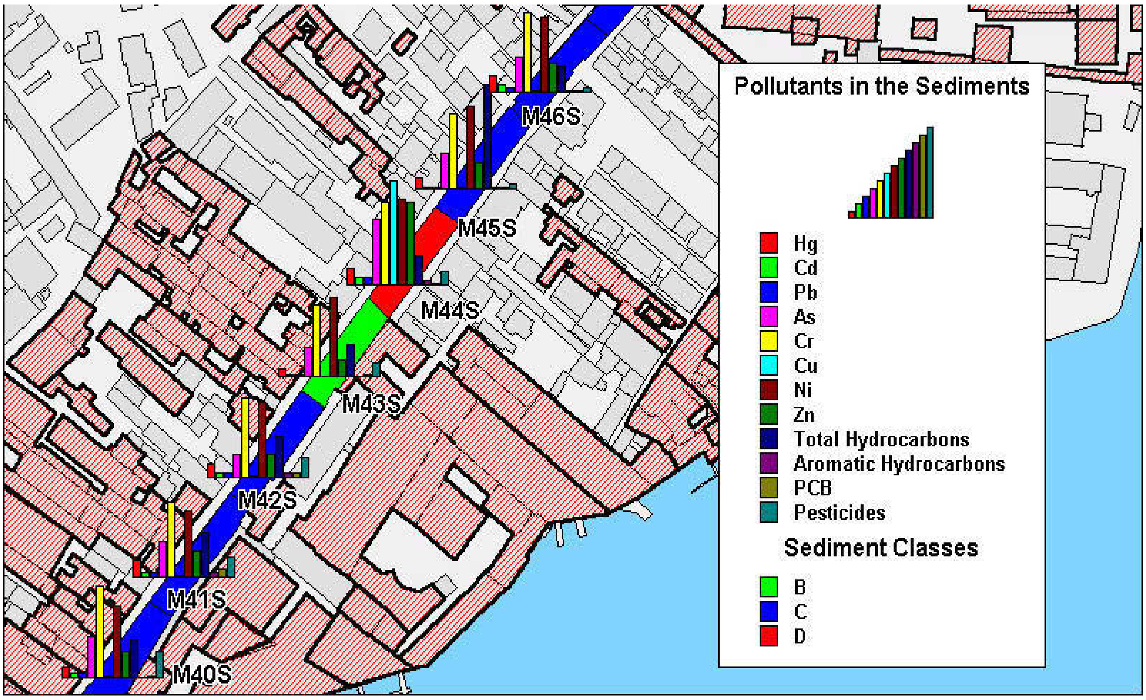

Figure 21 Levels of sediment pollution

Figure 21 is a representation of the levels of the different types of contaminants recorded in the sediments. The levels of contamination are shown in comparison to the other data sources recorded on Murano. The legend on the right shows what each color of the bar graph represents. It was intriguing to see that there was a class B and a class D sediment location right next to each other as shown by locations M43S and M44S respectively. In most locations the changes in levels of pollutants were not very different in two adjoining sampling locations. We checked at the location for any reason that they would be so different, especially since the class B sediment is right in front of a glass manufacturer and the D class is not. We could not find any noticeable reason why this would be the case. As can be seen by the bar charts the class D sediment has higher concentrations of copper, chromium, arsenic, and zinc. Most noticeably is the great increase in the concentration of copper. It would be beneficial in the future to further test these areas to determine why this drastic change occurs.

One problem that exists with the sediment data is that for several of the canals (all those shown by regions on the map rather than hexagon-shaped points), is that the exact measurement location was not recorded. In addition the regions have been classified based on small samples. In order to get a more accurate picture of the levels of pollutants in the sediments of Murano, more testing points are necessary.

4.9. Noise Pollution

ARPAV conducted tests for noise pollution beginning June 12, 2000. The twenty three monitoring stations (see Figure 22) provide extensive coverage of the glass manufacturers of Murano.

We assisted ARPAV and the *Settore Sicurezza del Territorio* with the installation of the equipment necessary for collecting the noise data and documented each installation with photographs. Even though

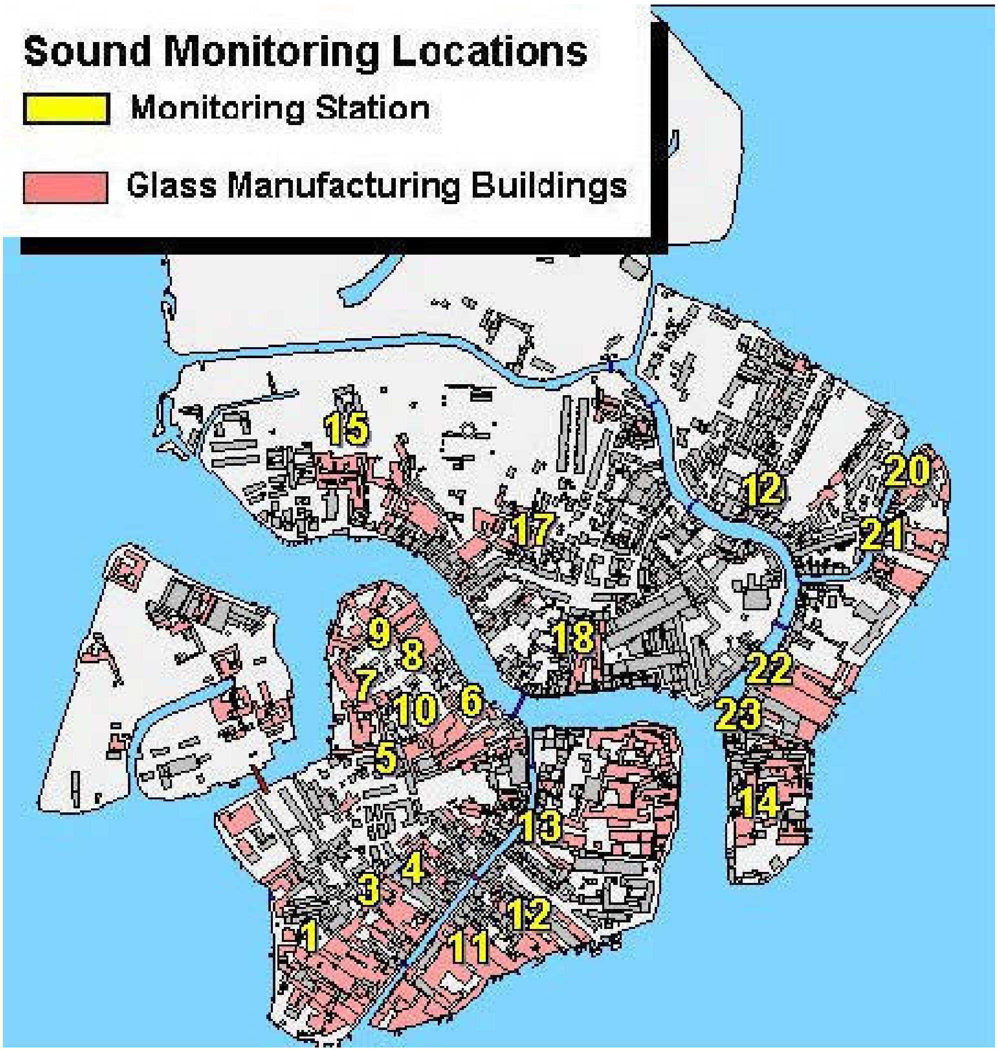

Figure 22 Noise monitoring locations

the data collected was not transmitted to us before the end of this project., they can be added to the pollution monitoring system in the future. The information will provide a model of the levels of noise produced by the glass manufacturers. Higher levels of noise can also be attributed to the times of day when peak operation occurs. During this time, multiple operations, such as grinding and polishing, occur simultaneously. Each of these operations contributes to the level of noise. Once the data has been received, an analysis will determine whether or not to monitor noise levels inside glass manufacturers. This will be based upon the levels recorded outside by the monitoring stations, as well as the number of complaints filed by residents.

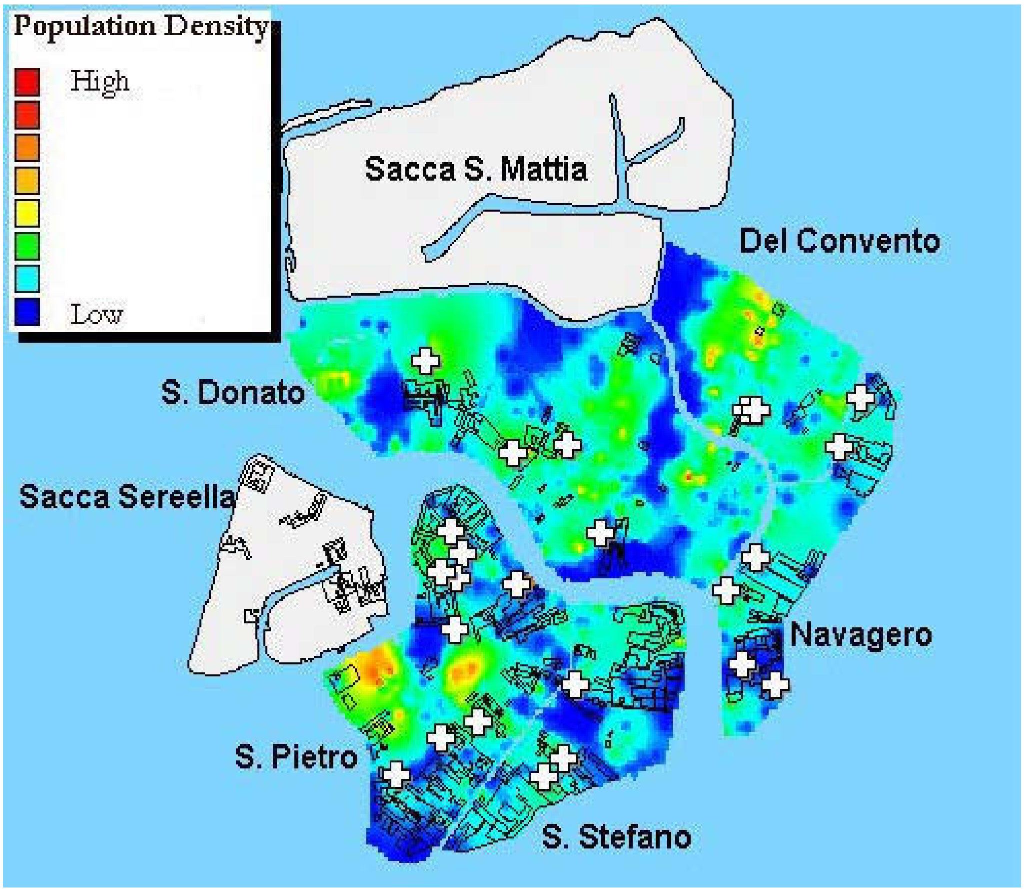

Figure 23 Noise monitoring locations and population density

Figure 23 shows the locations of the noise monitoring locations relative to the population centers of Murano. In the figure, the noise monitoring locations are the white plus symbols, the glass factories are depicted by the black outlined regions, and the population density is shown by the range of colors from dark blue, being areas of low density, to red, which are regions with high density. As can be seen, the noise monitoring location in the southern end of San Pietro is in a high population area surrounded by glass manufacturers. In fact, this location was chosen due to the high number of complaints by residents concerning excessive noise. Had this map been used during the selection of noise monitoring sites it might have yielded even better testing locations, and hence better results. The testing sites that are located in less dense areas are still necessary, though, in order to provide a complete picture of the noise pollution on the island.

A less than desirable result of the noise pollution testing procedures was that one of the glass manufacturing industries closed its operations during the monitoring period. The employers could see the installation and the owner was concerned, defensive, and annoyed. He proceeded to call the *Ecologia* and ask why they did not tell him in advance that they were planning on monitoring noise pollution. In response, the *Ecologia* said that they were not obligated tell him about the microphones because they were monitoring outdoor noise levels. In the end both sides were upset with each other and no usable data was gathered from that station.

4.10. The Pollution Monitoring System

At the completion of this project, we compiled as much data into our database as was made available. The GENERALITA_EDIFICIO table contains 172 records. Addresses exist for all the buildings. Summarizing the different area fields of the table, we find that the facilities of the glass manufacturers of Murano occupy over 197,100 square meters, approximately 141,200 square meters of that is covered and 55,900 square meters uncovered. Twenty six buildings contain *fosse*. The table identifying each of the glass manufacturing business, GENERALITA_AZIENDA, has 156 companies. We have obtained telephone numbers for 109 companies, fax numbers for thirty four, and email addresses and webpages for two. This information will allow the *Ecologia* to easily contact the manufacturers. Of the 70 companies that have signed the accord, the table includes the names of 54 legal representatives. The GENERALITA_STABILIMENTO table also has 156 records, since no differentiation was made between a glass manufacturer and the other, non-related activities a company may have. Amongst the data we collected on the glass manufacturers, we have their primary ISTAT code. In the table named CODICI_ISTAT we have twenty four records, each with a description of the activity for the code. The database also has information on 106 chimneys in the GENERALITA_CAMINI table.

Some fields in the database were not completed within the time frame given for this project. Certain information is currently not available for all of the manufacturers. Recognizing the need for future data entry and updates, the pollution monitoring system was created to accommodate new information.

5. CONCLUSIONS AND RECOMMENDATIONS

This chapter of the report is dedicated to making recommendations to the *Comune di Venezia* as well as the glass manufacturing companies that exist on Murano. These recommendations are geared towards using and upgrading the pollution monitoring system developed by our project team. Suggestions on providing a better organizational system for the information contained by the *Comune di Venezia* and the glass manufacturers are also addressed. Included in our recommendations are possible tests that could be performed in order to produce a better representation of the pollution that exists on Murano. Finally, we offer suggestions towards the use of pollution abatement technologies as well as personal safety techniques for the benefit of the glass manufacturers of Murano.

5.1. Upgrading the Pollution Modeling System

The pollution modeling system developed by our team was designed to be easily upgradeable, consequently it must periodically be upgraded and brought up to date. As stated earlier, many companies change their company information. Companies are frequently being absorbed into other companies or change their property holdings. Many new companies also appear from year to year. In order to have an accurate tool to monitor pollution, it is necessary to update the database with information from these new and reorganized companies. There are many different methods of accomplishing this. A form sent out regularly containing various company information such as their location, name, owner, primary activity, number of employees, and a request for a photograph of their entrance should be utilized. Legislation requiring companies to fill out the survey may be necessary, but incentives such as tax breaks may also be used to encourage manufacturers. This form includes a map depicting the perimeter of their company. If the company has recently changed its structure, or sold property, the proprietor could sketch in the changes in their perimeter. This provides an accurate method of upgrading the buildings owned by that company, if records in other government departments are unavailable. The proprietor of the company would have to completely verify the information contained within this form. The proprietor would also have to provide his signature as well as the signature of a witness. The signatures would serve as a legal method of binding the proprietor to the information that he provided so that, in the unfortunate case that someone would supply incorrect information, appropriate legal action could be brought against that company. We have included a possible design for this form in Appendix J. If the company is just starting the form would be a blank version of the form for the company to fill out and return

Another step in upgrading the pollution modeling system would be to require all manufacturers to send in copies of the blueprints of their buildings. This would allow for the insertion of information on all the inner workings of the company that could then be used to connect furnaces to chimneys, and settling tanks to pipes and machinery and sewer lines. These sewer lines could then be connected to the canals. This would provide a better knowledge of the location of discharge into the canals of all the glass manufacturing companies. New companies would have to fill out a more detailed form before being allowed to operate. The form would contain all the fields necessary to include, accurately and fully, their company into the database of the pollution modeling system developed by our team.

5.2. Tests

In order to provide a better representation of the pollution levels that exist on Murano it is necessary to perform a comprehensive series of tests. Our project dealt with information that was incomplete and up to five years old. To sufficiently monitor levels of pollution one needs to have information from multiple sources. This information must be collected frequently.

5.2.1. Testing Canal Sediments

The pollution levels observed in the sediment provide a starting point, an indication of the pollution that exists within the canals. Future tests should include testing multiple points throughout the seven canals of Murano. These points will allow the user to draw up a more complete representation of the pollution that exists within the canal system of Murano. In the past few years the number of manufacturers on the island of Sacca Serenella has rapidly increased. The first location to test would be Canale Serenella. There were no tests performed there during the 1995 survey performed by the *Ecologia*. This should be tested to establish a baseline for the twelve manufacturers located there. This can be used

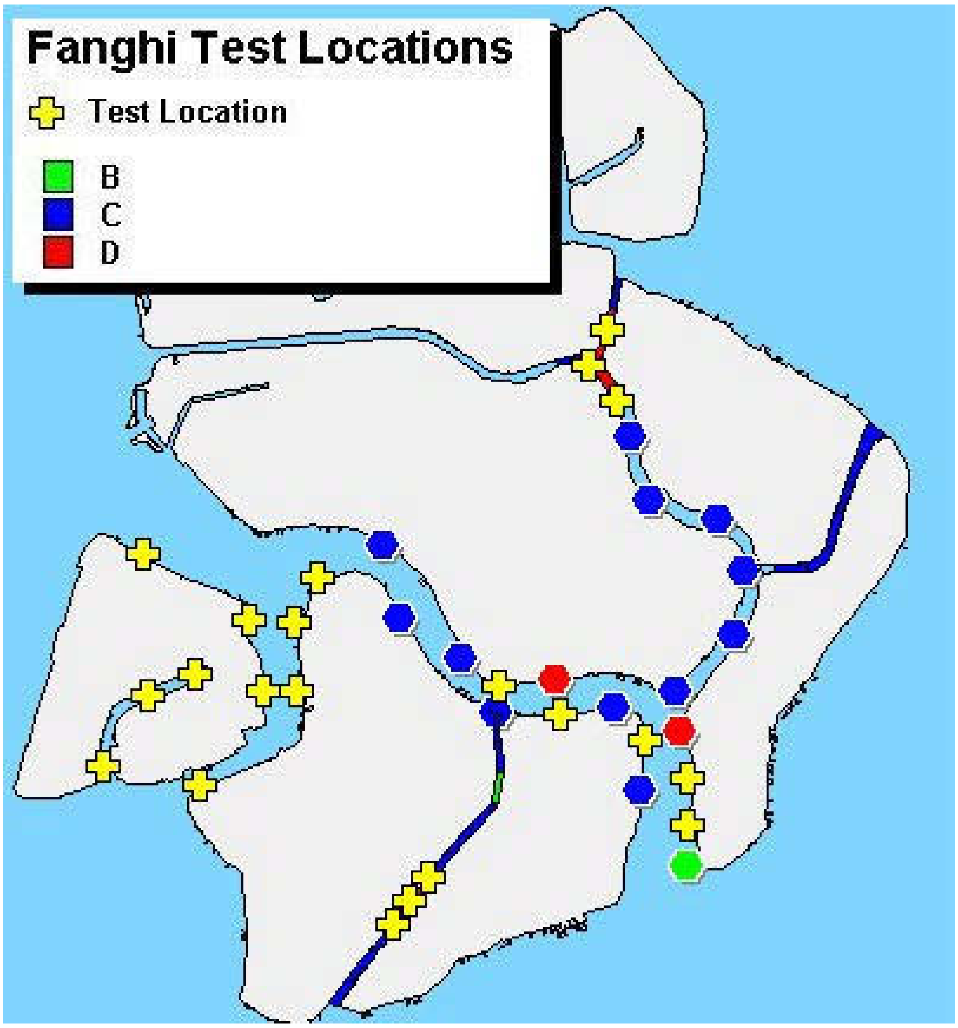

Figure 24 Possible sediment test locations

to show the impact these manufacturers have on the canal. As shown by the analysis of pollutants in sediments, on average there is not much variability from one region to the next. However, in locations where two strongly contrasting sediment classes are observed, such as along Rio dei Vetrai, where there are class B and class D sediments adjacent to each other, more testing would provide better information. Finding the points at which the pollutants' concentrations change could lead to finding the cause of the pollution. Figure 24 locates possible sites to be examined in the future. Finally, when these tests are carried out the exact locations of each sample in longitude and latitude should be recorded. This way the data can be plotted exactly in the pollution monitoring system. Implementing a testing plan for all locations, on the order of once every ten years, may prove useful to track changes in sediment quality.

5.2.2. Testing Effluent Waters

Monitoring sediments is a good way to determine the health of a canal, but pollutants located in the sediment cannot be attributed to any single source. In order to figure out what is causing the buildup of certain sediment pollutants, it is necessary to test the effluent waters of companies. We have two approaches to this. First, testing can be done on the sediments left in the settling tanks of companies. This will give an accurate measure of the types of pollutants being emitted in the wastewater of companies. We have already coded the tanks on the authorizations provided to us so the data can be easily attached to the pollution monitoring system.

The second procedure that would be useful is to test the water being emitted into the canals by each company. This could either be done at the effluent point of the septic tanks, or at the point where the effluent enters the canal. This information would tell exactly what each company is emitting in its effluent and at what levels. This information combined with the sediment data would give a complete picture of the pollution in the canals.

5.2.3. Recommendations for Testing Noise Pollution

As mentioned in the previous section of this paper, the selection of noise monitoring stations would benefit from the use of the population density map. The purpose of the recent noise monitoring was to follow up on complaints and gather a sample of noise levels produced by glass manufacturers. To gather a better model of the noise generated by the glass industry, it is important to collect data from companies in high and low population areas. Manufacturers in populated areas will most likely generate more complaints about noise than manufacturers in sparsely populated regions. Meanwhile, the glass manufacturers with few or no residents around could be the greatest violators.

We suggest using the population density map created by the project team to assist in selecting future noise monitoring stations. An equal number of stations should be selected near manufacturers in low (blue), medium (green), and highly populated areas (red). Regions with numerous complaints, regardless of population density, should be given priority. After several stations are selected by this standard, all other stations should be selected in order to balance out the distribution of stations across the island and through high and low density areas. For example, assume twenty four monitoring stations are desired. If ten stations are selected based on complaints and are distributed so that eight are in highly populated areas, one in a medium ranged area, and another in a low density area, the remaining fourteen stations should greatly favor low density areas. Ideally, eight stations at each range are desired, but resident cooperation and other factors can make such a distribution difficult. Also, if the majority of the ten stations tend to favor one section of Murano, for example, the southern end of San Pietro, it would be desirable to locate the remaining stations more evenly throughout Murano.

A benefit of using this method for selecting monitoring stations is that it would create data for a defined range of areas. After data is collected, a trend may emerge correlating population density to noise level. For example, a probable scenario is that manufacturers in areas with low population are the worst violators of noise regulations. A pattern such as this would provide firm ground for the *Ecologia* to test a majority or all manufacturers in similar regions.

5.2.4. Testing Air Emissions

Our project only contained data from the authorized emissions of the chimneys of sixteen companies. In order to provide a means of monitoring the levels of emissions produced from the glass manufacturers, it is necessary to obtain information from all the companies that use chimneys. This information includes not only the regulated sizes and levels, but also the actual emission levels being emitted by manufacturers. The information should be obtained as the companies who signed the accord file for their chimney permits. In addition, it would be useful to learn the types of abatement technologies being applied on each chimney. Data could be collected to show which technologies are most efficient for each application.

After the chimneys have been installed and are operating, a baseline reading for pollutants should be taken. After this, the emissions from the chimneys should be tested yearly (at random) to obtain an accurate image of the emissions being released by the individual companies. This would be done for the first few years under the accord, and then could be relaxed to a random sampling of some of the companies yearly. This data would be used to track changes in production of pollutants over time.

Finally, an overall air quality station for the island should be established. This should be monitored and compared to the emissions from the companies. A comparison could then be worked out showing ratios of pollutants made by the glass manufacturers to those of the air for the region. This would show what kinds of pollutants were coming from areas other than Murano.

5.3. Pollution Abatement Techniques

The problem now observed by the glass manufacturers is that they need to reduce the output levels of pollution. Currently there are two steps that can be taken. The first one is to install a chimney; the second step is to install a septic tank. A chimney provides a means of monitoring the emission levels released by the company. A chimney also serves as a beneficial location to place pollution abatement technologies. Within the chimney one is capable of installing various filtration devices that are designed to remove many of the pollutants that are released during combustion. These filters act in the same manner as the muffler on an automobile. In order to maintain the traditional aesthetics, one could very easily hide the chimneys by placing the chimney into a cement or brick casing. This would provide a natural appearance and not one of a modern manufacturing plant. Every company should install a septic system. These septic systems provide a means of filtering out the sediments from the water. An alternative to the typical septic system is to install a water-recycler. A water-recycler operates by filtering out the sediments and chemicals that are in the water. The clean water is then capable of being reused. The systems can be installed in a separate room where no one will see it. The device is very easy to install and maintain. In order to maintain the device, one must regularly change the filters according to the amount of usage. The two steps previously described will allow the glass manufacturers to meet the environmental regulations currently imposed upon them. The companies should then promote their environmentally safe image to enhance their reputations.

5.4. Reduction of Energy

Excessive amounts of energy are consumed in order to generate the levels of heat required to melt glass. However, much of this energy is wasted as heat given off to the environment. We recommend finding ways to use this heat. Possibilities include cogeneration to use the excess heat from some furnaces to help heat others. Another possibility is using the heat for other applications in the building such as for the water boilers. If the heat cannot be used by the companies perhaps it could be used to heat homes, or provide power to residents. This would not only reduce the energy required, but could also reduce costs for the companies.

5.5. Occupational Safety

The safety of the workers should be of the utmost importance. While completing our survey of the companies, we noticed through on-site observations many areas of concern towards the safety of the employees of the company. The following observations and suggestions are peripheral to the main focus of our project, but we wanted to make note of them. The conditions of many glass making facilities were mediocre at best. A significant amount of solid waste, such as glass fragments, could be observed in many of the regions where employees perform their jobs. We also noticed the lack of safety equipment such as gloves, masks, and safety glasses. Within the mixing room people become exposed to the dust that is generated during mixing. This dust contains a mixture of chemicals. Wearing gloves and masks for these operations would dramatically reduce the exposure of employees to the easily inhaled dusts. It is important for the companies to find a balance between worker safety and the appearances they wish to project.

Many of the chemicals and components used to create glass are in containers that are not labeled. We saw many of these components spilled onto the ground. Also, all containers should be properly labeled and stored in regions where they will not be tampered with. Included on these labels should also be a safety code and steps to take if accidentally misused. These safety labels and information should be in a similar form to the Materials Safety Data Sheet (MSDS). A sample MSDS can be found in Appendix I.

Another important safety step involves what happens after a chemical spill. We witnessed numerous shops in which the coloring chemicals had spilled onto the floor and were left in a pile. It is very advantageous, to both the health of the workers, and to reducing pollution, if the companies cleaned up the spill by placing the waste into a properly labeled chemical waste container. The containers are then sealed and sent to a waste management company for processing chemical wastes. This is common practice in laboratories throughout the world.

In order to facilitate the adoption of these practices, the *Comune di Venezia* could issue a memorandum that describes safe production practices and the recommendations for companies. This could be updated and delivered yearly to the companies.

5.6. Data Organization

In our attempt to acquire information from the *Comune di Venezia* we came across numerous problems. Multiple departments within the *Comune di Venezia* , and the *Provincia* had the information that was pertinent to our project. It was difficult to go through multiple departments to find information concerning one primary area. Once the data was obtained, it was often incomplete, or misleading. One example is the blueprints of companies authorized to have chimneys. Some of the blueprints we received were either labeled incorrectly, not labeled at all, or had nothing to do with the company they were supposed to be. In addition, some of the blueprints did not even denote the information that was necessary to obtain a chimney permit. Also, the risk of re-performing work done by another group is increased due to the lack of proper organization of information.

Another problem that we encountered was that not every department had the information that was needed to do their job, and that only one copy of the information existed. In the future multiple copies of information such as the blueprints, and permit information should be made and distributed to whoever needs them.

A system should be organized in which all departments share this information freely. In addition the information should be computerized for easy searches and retrieval, as well as for communication with other departments.

5.6.1. Networked Computer System

Storing all data relative to the glass manufacturers of Murano in one location would provide an easy outlet for the transferal of information from one department to another. All hard copies of the data would be located in one location. Whenever a person needed to view this information it would be available for reproduction. Storing the data in one primary location enables a user to find all the data available that is pertinent to the subject at hand. The use of a networked computer system takes this recommendation one step further. If every computer within the *Comune di Venezia* were linked together then everyone would easily be able to acquire and transfer data. This also eliminates the paper trail because everything would be available via computer. There are substantial benefits to the adoption of such a computer system. Use of the system can be restricted to one department or group of people via passwords. One is also capable of permitting the transferal of data outside of the networked system. The most substantial benefit to networking the *Comune di Venezia* is that a user is capable of acquiring information from many other departments that might be useful in their analysis.

5.7. Company Organization

Organizing a company's resources is useful because it allows someone to easily evaluate the current condition of the company. There are many different levels in which company organization can be done. Many companies throughout the world follow an ISO standard. ISO 9000 is rapidly becoming the most popular quality standard in the world. Thousands of organizations have already adopted this important standard, and many more are in the process of doing so. ISO 9000 applies to all types of organizations. It does not matter what size they are or what they do. It can help both product and service oriented organizations achieve standards of quality that are recognized and respected throughout the world.

The procedure is as follows. A company decides that they need to develop a quality system that meets the ISO 9000 standards. Companies choose to follow this path because they feel the need to control the quality of their products and services, to reduce the costs associated with poor quality, or to become more competitive. Or, they choose this path simply because their customers expect them to do so or because a regulatory body has made it mandatory. The next step is to develop a quality system that meets the quality requirements specified by one of the following three standards: ISO 9001, ISO 9002, or ISO 9003. The glass manufacturers of Murano would follow an ISO 9001 standard. ISO 9001 is for organizations that design, produce, install, and service products In the course of doing so, you also consider ISO's main guidelines. These guidelines include ISO 9000, ISO 9004, ISO 10011, and ISO 10013. Once a quality system has been developed and implemented, a company carries out an internal audit to make sure the system is working properly. After the internal audit is performed an accredited external auditor (registrar) must evaluate the effectiveness of the quality system. If the auditors are satisfied, they will certify that the company's quality system has met all of ISO's requirements. They will then issue an official certificate to the company and record your achievement in their registry. The company can then announce to the world that the quality of your products and services is managed, controlled, and assured by a registered ISO 9000 quality system.

The reputation of ISO is very high. We recommend that the glass manufacturing companies on Murano adopt a similar program. The process of organizing the glass manufacturers would involve documentation providing the amounts of resources used. These resources would include the amount of gas, water, and electricity used monthly by the plant. All materials consumed must also be documented. In addition all the equipment used and the processes undergone at the plant would be documented. This information could then be used by the *Comune di Venezia* to augment the pollution monitoring system. The requirements for ISO 9001 certification have been included in Appendix D.

5.8. Future Projects

In completing this project we realized other opportunities where WPI students could help the *Comune di Venezia*, as well as the Murano glass manufacturers. Our ideas for these future projects are presented below.

5.8.1. Sewage Outlets on Murano

In order to test the effluent as it enters the canals on Murano as recommended earlier, one must know where the sewer outlets are. A past WPI project team mapped the sewer outlets into the canals of Venice. Using a similar methodology to locate all of the outlets on Murano would be very beneficial. In order to facilitate this, all the companies should submit blueprints detailing their outlet sources. Maps similar to the one we created in Figure 19 could be generated to assist the surveying of sewers. This would greatly facilitate the testing recommended earlier of the effluent flowing directly into the canals.

5.8.2. Energy Consumption on Murano

This project could investigate the energy used by glass manufacturers, other industries on Murano, and residents. Its purpose would be to find ways to maximize energy efficiency. One possible topic would be the feasibility and advantages to using cogeneration technology with the furnaces of glass manufacturers.

5.9. Project Conclusions

The previous recommendations were developed to upgrade and expand upon the pollution monitoring system, as well as methods for glass manufacturers to improve their facilities and to enable the manufacturers and the *Comune di Venezia* to achieve the goals of the glass accord. The majority of our recommendations suggested the use of technology to improve upon the safety and methods of production, as well as the efficiency and completeness of pollution monitoring. When implementing technology, it is important to consider how it effects society.

The benefits of technology can be measured by their contribution to the needs of society. In completion of this project, we created a tool that assists the *Settore Sicurezza del Territorio* in monitoring the pollution caused by the glass manufacturing companies of Murano. The immediate use for the pollution monitoring system will be to record the progress of glass manufacturers in meeting the provisions of the *Accordo sul Vetro.* The tool will be used after the grace period of the accord has expired for the continual and long-term monitoring of the pollution caused by glass manufacturers. Although this project was focused upon the glass manufacturers of Murano, the pollution monitoring system we created is easily adaptable to assist in the monitoring of pollution caused by other sources. Society demands that companies utilize the technology available to them to minimize their negative impact on the environment. Although this tool was created for use by *the Settore Sicurezza del Territorio,* its true impact will be seen in the benefits it provides to the glass manufacturers of Murano. If used successfully, the products of this project, especially the pollution monitoring system, will preserve the traditional glass industry of Murano while minimizing the pollution glass manufacturers emit into the environment. Hopefully, our project will aid in the preservation of the tradition of Murano glass for many more centuries and improve the condition of the Venetian lagoon environment.

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World Press. "6/6 Mercury & Dioxins in Shellfish in Venice Lagoon." 6/6 Mercury & Dioxins in Shellfish in Venice Lagoon. http://www.greenpeace.org/ majordomo/index-press-releases/1996/msg00147.html (April 2, 2000).

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7. APPENDICES

7.1. Appendix A - Annotated Bibliography

Camuffo, Dario. "Indoor air quality at the Correr Museum, Venice, Italy." The Science of the Total Environment. Vol. 236 Issues 1-3, September 15, 1999: 135-152.

Research paper focusing on the effects of heating and air conditioning on the movement and deposition of pollutants on paintings in the Correr Museum in Saint Mark's Square. The article has some good information on what certain pollutants do to paintings. Also touches upon the origination of these pollutants. Article also mentions details of bacteria movement and heat and humidity distribution, and their effects on paintings, but that is of little concern for researching this project.

Christensen, Per and Susse Georg. "Regulatory Effects in the Electroplating Industry –A Case Study in Denmark." J. Cleaner Prod. Vol. 3, No. 4 (1995): 221-224.

This is an interesting article that evaluates how effective environmental legislation was in Denmark on electroplating firms. These firms were forced to reduce their waste of heavy metals. The companies complied, and the article goes into some detail of how they did this and approximately how much it cost. This information can be applied to heavy metal abatement for the glass industry on Murano.

Education Department of the Corning Museum of Glass. A Resource of Glass. http://www.cmog.org/Education/edglass.htm (May 30, 2000).

A good overview about the history of glass, glass manufacturing, pollution from glass, and various other topics concerning glass. This WebPages was an excellent source, providing much of the information for our research. Whenever one has a question concerning glass, A Resource of Glass is definitely the first place to look for the answer.

Encyclopedia Britannica.com. Murano. http://www.brittanica.com/bcom/eb/article/6/0/5716/55686+1,00.html (March 28, 2000)

Encyclopedia Britannica online has several articles of interest on glassmaking, the history of Venice, and the history of Murano. These articles are not very detailed but together provide a good overview and starting point for an understanding of Murano.

Ecologia, Accordo Di Programma Per Il

Miglioramento Dell'Impatto Ambeientale Generato Dalle Aziende Produttrici Di Vetro Artistico Situate Sull' Isola Di Murano-Venezia, 1999 (Venice, Italy)

This is the document that establishes the need for our project. The Ecologia is establishing new environmental regulations for the glass manufacturers of Murano to meet by December 31, 2002.

Freeman H.M. ed., Standard Handbook of Hazardous Waste Treatment and Disposal, (New York: McGraw Hill Book Co. 1989)

A very in-depth source on waste management, procedures, and technology. The majority of the pollution abatement techniques were researched form this source. In addition it gives some cost estimates, concise tables summarizing the information, and by far the best source we looked at for waste management. The focus of the book is on solid and liquid wastes however, so it does not have any information for air pollution

Hadjiioannou, Alexis. Heavy Metal Toxicity. http://website.lineone.net/~alexaras/index.html (April 3, 2000).

This is a good introductory webpage about the toxicity of metals. Information seems accurate and professionally done. The page is limited only to a select few metals, so it's usefulness for the project is limited.

Lane, Frederic C. Venice A Maritime Republic. Baltimore MD: Johns HopkinsUniversity Press, 1973.

This book provides and exceptional history of Venice. Though there is not much specific information about Murano (4 pages at most) the book provides accurate and detailed historical settings. Not necessarily a book geared for this project, but essential background for studies of Venice.

Manahan, Stanley E. Toxicological Chemistry. Chelsea, MI: Lewis Publishers, Inc., 1989

Very in depth book about the chemistry of toxins. Primarily explains toxicology on a molecular level. Identifies the most toxic substances in a defined category and gives accounts of known effects and treatments for it. Covers elemental, organic, non-organic, and narrower categories of toxins.

The book gives a broad overview of the effects of toxins in the body. However, it is not too specific on metal toxins used in the glass industry because the author focused on the most harmful toxins.

Paul, A. Chemistry of Glasses. London: Chapman and Hall, 1982.

This is an in depth source. It goes into much detail about the properties of glass and the chemistry behind them. Very detailed.

Sittig, Marshall. Handbook of Toxic and Hazardous Chemicals and Carcinogens. Park Ridge, NJ: Noyes Publications, 1985.

This book is a listing of hundreds of elements and compounds complete with description, potential ways of exposure, harmful effects, first aid, and disposal methods for each. Very complete and useful reference.

Society of Chemical Industry. "Eichem Under Fire In Venice." Water Pollution. http://ci.mond.org/9510/951003.html (March 29, 2000).

This webpage is of an article about a Greenpeace report on the pollution in the Venetian lagoon caused by Eichem's petrochemical industries. Good starting point to identify how polluted the lagoon is relative to other bodies of water and the cause of much of this pollution.

Way, Al and Ginny. 162 Glass Insulator Color. http://www.come.to/162color (April 10, 2000).

Concise and interesting site about color and glass. Many pictures of different colors in glass and good summation of what color is and how it is added to glass. Most useful for its listing of metals and the colors they tend to form in glass.

World Press. "6/6 Mercury & Dioxins in Shellfish in Venice Lagoon." 6/6 Mercury & Dioxins in Shellfish in Venice Lagoon. http://www.greenpeace.org/ majordomo/index-press-releases/1996/msg00147.html (April 2, 2000).

Article regarding the high levels of mercury and dioxins found in the Venetian lagoon. The article is not too specific, since it's just a news article, but it does give an idea about the lagoon's condition and the fight against pollution.

7.2. Appendix B – Glossary of Italian Terms

Italian	English meaning
Accordo sul Vetro	short for the Glass Accord signed in May 2000
acidatura	acid bath room
acido fluoridrico	hydrofluoric acid
altra	other
antimonio	antimony
arsenico	arsenic
autorizzati	authorized
azienda	business
Azienda Communale di Transporti di Venezia (Actv)	Venetian public transportation authority
cadmio	cadmium
camini	chimneys
campi	squares
canale	canal
caratterizzazione	characterization
cerio	cerium
civico	street number
classificazione	classification
cobalto	cobalt
codice	code
composti	compounds
Comune di Venezia	Government of Venice
condensagrasse	grease settling tank
ditta	company name
edificio	building
emmisione	emissions
fanghi	sediment
fondamente	main walkways along canals
fornace	furnaces
forcelanti	glasscutters
fosse	tanks
fosse settiche	settling tanks
fumi	smoke
fusione	furnace for initial melting of glass
garzonetti	little boy workers
garzoni	glass workers
indirizzo	address
inquinamento	pollution
isola	island
ispezionabile	inspectable
ISTAT	an Italian code that describes the activities of a company
magazzino	store room
molerie	grinders

nome ragione	legal name
nichel	nickel
organici	organic
ossidi di azoto	nitrous oxides
particelle sospese totali	particulates
piombo	lead
pozzetti	drains
Provincia	provincial governing body
rame	copper
riscaldament	furnace for reheating glass to work
rumore	noise
sacca	land reclaimed in recent times
sacche	reclaimed land zones
scarichi	pipes
Scarichi fognari	main discharge pipes
selenio	selenium
serventi	servants
stabilimento	establishment
stagno	tin
tempera	furnace for keeping glass at a temperature
ufficio	office
vani	interior rooms
vetrerie	glass manufacturers
vetro	glass
volatili	volatile

7.3. Appendix C – Glossary of Technical Terms

Technical Term	Description
adsorption	the accumulation of gases,liquids, or solutes on the surface of a solid or liquid
anneal	the slow cooling of glass in order to harden and make it less brittle
crucible	a vessel made of heat resistant material
effluent	stream of liquid, gas, or solid that is emitted from a particular system
flocculate	to form lumpy and fluffy masses
influent	stream of liquid, gas, or solid that is input to a particular system
ions	charged atomic or molecular particles
mandrel	a rod or bar around which glass is shaped
MSDS	Material Safety Data Sheet, shows information about toxicity, treatment, and other safety information for chemical compounds.
resin	viscous substance that does not conduct electricitiy
SPL meter	Sound Pressure Level meter, measures the pressures of all sound waves at a given point
substrate	solution that is to be filtered or purified

7.4. Appendix D – ISO 9001- Steps for Compliance[53]

ISO 9001 Translated into Plain English

ISO 9001 is for Organizations that Design, Produce, Install, and Service Products

ISO 9001 is a Quality Assurance Model made up of Quality System Requirements

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ISO 9001 is a quality assurance model made up of 20 sets of quality system requirements.
This model applies to organizations that design, develop, produce, install, and service products. ISO expects organizations to apply this model, and to meet these requirements, by developing a quality system.

ISO 9001 4.1 - Management responsibilities

- Define a quality policy. Your policy should describe your organization's attitude towards quality.
- Define the organizational structure that you will need in order to manage your quality system.
    - Define quality system responsibilities, give quality system personnel the authority to carry out these responsibilities, and ensure that the interactions between these personnel are clearly specified. Also, make sure that all of this is well documented.
    - Identify and provide the resources that people will need to manage, perform, and verify quality system work.
    - Appoint a senior executive to manage your quality system and give him or her the necessary authority.
- Define a procedure that your senior managers can use to review the effectiveness of your quality system.

ISO 9001 4.2 - Quality system requirements

- Develop a quality system and a manual that describes it.
- Develop and implement quality system procedures that are consistent with your quality policy.
- Develop quality plans that show how you intend to fulfill quality system requirements. You are expected to develop quality plans for products, processes, projects, and customer contracts.

ISO 9001 4.3 - Contract review requirements

- Develop and document procedures to coordinate the review of sales orders and customer contracts. Make sure you include the customer in the process of review.
- Your contract review procedures should ensure that all contractual requirements are acceptable before you agree to provide products or services to your customers.
- Develop procedures which specify how customer contracts are amended, and which ensure that changes in contracts are communicated throughout the organization.

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[53] ISO 9001 Translated into Plain English. Praxion Research Group Limited. http://connect.ab.ca/~praxion/9001.htm (January 9, 2000).

- Develop a record keeping system that you can use to document the review of customer orders and contracts.

ISO 9001 4.4 - Product design requirements

- Develop and document procedures to control the product design and development process. These procedures must ensure that all requirements are being met.
- Develop product design and development planning procedures.
- Identify the groups that should be routinely involved in the product design and development process, and ensure that their design input is properly documented, circulated, and reviewed.
- Develop procedures to ensure that all design input requirements are identified, documented, and reviewed; and that all design flaws, ambiguities, contradictions, and deficiencies are resolved.
- Develop procedures to control design outputs.
- Develop procedures that specify how product design reviews should be planned and performed.
- Develop procedures that specify how design outputs, at every stage of the product design and development process, should be verified.
- Develop procedures that validate the assumption that your newly designed products will meet customer needs.
- Develop procedures to ensure that all product design modifications are documented, reviewed, and formally authorized before the resulting documents are circulated and the changes are implemented.

ISO 9001 4.5 - Document and data control

- Develop procedures to control quality system documents and data.
- Develop procedures to review, approve, and manage all of your quality system documents and data.
- Develop procedures to control changes to documents and data.

ISO 9001 4.6 - Purchasing requirements

- Develop procedures to ensure that purchased products meet all requirements. These procedures should control the selection of subcontractors, the use of purchasing data, and the verification of purchased products.
- Develop procedures to select, evaluate, monitor, and control your subcontractors (your suppliers). Make sure that quality records are kept which chronicle the performance of all your subcontractors. Your records should identify the acceptable subcontractors and the products and services they provide.
- Develop procedures to ensure that your purchase order documents precisely describe what you want to buy.
- Develop procedures that allow you or your customers to verify the acceptability of products you have purchased.

ISO 9001 4.7 - Customer-supplied products

- Develop procedures to control products supplied to you by customers. These procedures should ensure that you:
    - Examine the product when you receive it to confirm that the right items were shipped without loss or damage.
    - Prevent product loss, misuse, damage, or deterioration through proper storage and security.
    - Record, and report to the customer, any product loss, misuse, damage, or deterioration.

    - Clarify who is responsible for the maintenance and control of the product while it is in your possession.

ISO 9001 4.8 - Product identification and tracing

- Develop and document procedures to identify and track products from start to finish. When appropriate, these procedures should ensure that you:
    - Identify and document products every step of the way from the purchase of supplies and materials through all stages of handling, storage, production, delivery, installation, and servicing.
    - Trace products or product batches by means of unique identifiers and suitable record keeping

ISO 9001 4.9 - Process control requirements

- Develop and document procedures to plan, monitor, and control your production, installation, and servicing processes.
- Design a record keeping system that monitors and controls process personnel and equipment. Make sure that all important process qualities are monitored and recorded.

ISO 9001 4.10 - Product inspection and testing

- Develop procedures to inspect, test, and verify that incoming, in-process, and final products meet all specified requirements. Also ensure that appropriate product inspection and testing records are developed, and that your procedures ensure that these records are properly maintained.
- Develop procedures that ensure that incoming products are not used until you have verified that they meet all specified requirements.
- Develop procedures that ensure that work-in-process meets all requirements before work is allowed to continue.
- Develop procedures that ensure that final products meet all requirements before they are made available for sale.
- Develop a record keeping system that your staff can use to document all product testing and inspection activities.

ISO 9001 4.11 - Control of inspection equipment

- Develop procedures to control, calibrate, and maintain inspection, measuring, and test equipment used to demonstrate that your products conform to specified requirements (the term equipment includes both hardware and software).
- Develop procedures to ensure that your measurement equipment is appropriate, effective, and secure.
- Develop procedures to calibrate all of your quality oriented inspection, measuring, and test equipment.

ISO 9001 4.12 - Inspection and test status of products

- Develop procedures to control the test status of your products. These procedures should ensure that:
    - Each and every product is identified as having passed or failed the required tests and inspections.
    - The test status of each product is documented and respected throughout the production, installation, and servicing process.
    - Only products that have passed all tests and inspections are subsequently used or sold to customers (unless an official exception is made under section 4.13 below).

ISO 9001 4.13 - Control of nonconforming products

- Develop procedures to prevent the inappropriate use of nonconforming products. Also make sure that everyone is notified when your products do not conform to specified requirements.
- Develop procedures to control how your nonconforming products are reviewed, reworked, regraded, re-tested, recorded, and discussed.

ISO 9001 4.14 - Corrective and preventive action

- Develop procedures to correct or prevent nonconformities.
- Develop procedures to ensure that nonconformities are identified and corrected without delay.
- Develop procedures to ensure that potential nonconformities are routinely detected and prevented.

ISO 9001 4.15 - Handling, storage, and delivery

- Develop and document procedures to handle, store, package, preserve, and deliver your products.
- Develop product handling methods and procedures that prevent product damage or deterioration.
- Designate secure areas to store and protect your products.
- Develop procedures that specify how your products will be placed into storage and removed from storage.
- Develop procedures that specify how your products will be protected from damage or deterioration during storage.
- Develop procedures that specify how your products will be monitored and evaluated to detect damage or deterioration while in storage.
- Develop packing, packaging, and marking methods and procedures to protect and control the quality of products and packaging materials.
- Develop methods and procedures to protect and preserve product quality prior to delivery and while the product is still under your control.
- Develop procedures to protect your products after final testing and inspection, and during product delivery.

ISO 9001 4.16 - Control of quality records

- Identify and define the quality information that should be collected.
- Develop a quality record keeping system, and develop procedures to maintain and control it. Develop procedures to:
    - Collect and record quality information (create records).
    - File, index, store, and maintain quality records.
    - Remove, archive, and destroy old quality records.
    - Protect quality records from unauthorized access.
    - Prevent records from being altered without approval.
    - Safeguard records from damage or deterioration.

ISO 9001 4.17 - Internal quality audit requirements

- Develop internal quality audit procedures which:
    - Determine whether quality activities and results comply with written quality plans, procedures, and programs.
    - Evaluate the performance of your quality system.
    - Verify the effectiveness of your corrective actions.
- These procedures should also ensure that:

    - Audit activities are properly planned.
    - Auditors are independent of the people being audited.
    - Audit results, corrective actions, and corrective action results and consequences are properly recorded.
    - Audit conclusions are discussed with the people whose activities and results are being audited, and deficiencies are corrected.
    - Audit reports are fed back into the quality system review process.

ISO 9001 4.18 - Training requirements

- Develop quality training procedures. These procedures must ensure that:
    - Quality system training needs are identified.
    - Quality training is provided to those who need it.
    - People are able to perform quality system jobs.
    - People have the qualifications they need to do the work.
    - Accurate and appropriate training records are kept.
    - Everyone understands how your quality system works.

ISO 9001 4.19 - Servicing requirements

- Develop and document quality service procedures. Your procedures should specify how:
    - Products should be serviced.
    - Product service activities are reported.
    - The quality of product service is verified.

ISO 9001 4.20 - Statistical techniques

- Select the statistical techniques that you will need in order to establish, control, and verify your process capabilities and product characteristics.
- Develop procedures to explain how your techniques should be applied.
- Develop procedures to monitor and control how techniques are used.
- Make sure that all statistical procedures are documented.
- Make sure that proper statistical records are kept.

7.5. Appendix E – ISTAT Code

ISTAT CODE	Descrizione	Description
2453		
247	Codice vecchio	old code
2472	Codice vecchio	old code
2473	Codice vecchio	old code
2474	Codice vecchio	old code
26	Fabbricazione di prodotti della lavorazione di minerali non metalliferi	Working and producing products made form materials other than metals
2610	Fabbricazione di vetro e di prodotti in vetro	Fabrication of glass and glass products
26100	Fabbricazione di vetro e di prodotti in vetro	Fabrication of glass and glass products
2612 A	Lavorazione e trasformazione del vetro piano (artigiane)	Working and transforming small glass objects (artisans)
2612 P	Lavorazione e trasformazione del vetro piano	Working and transforming small glass products
2613	Fabbricazione di vetro cavo	Fabrication of glassware
26152	Lavorazione di vetro a mano e a soffio	Working of glass by hand or blowing (industrial)
26152 A	Lavorazione di vetro a mano e a soffio (artigiane)	Working of glass by hand or blowing (artisans)
26152 P	Lavorazione di vetro a mano e a soffio	Working of glass by hand or blowing (primary)
26153	Fabbricazione e lavorazione di altro vetro (vetro tecnico e industriale per altri lavori	Fabrication and working of other glass products (i.e. technical and industrial glass)
31		not available
3141		not available
3221		not available
347		not available
4631		not available
4911		not available
6482		not available
6495		not available
9231	Creazioni e interpretazioni artistiche e letterarie	Creation and interpretation of art and letters

7.6. Appendix F – Code syntaxes and examples

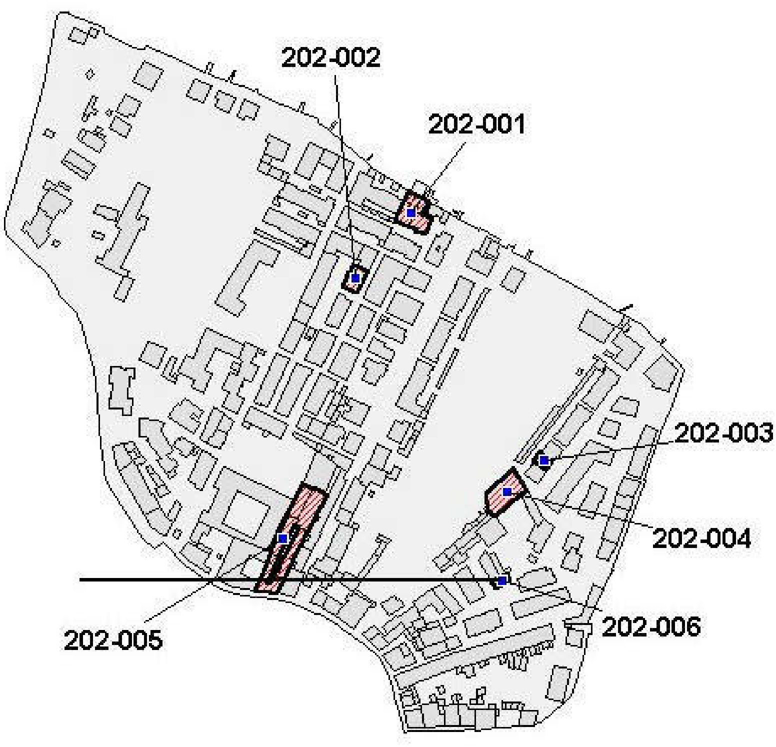
7.6.1. Island Codes

Every island in the Venetian Lagoon has been assigned a number. The following table shows a list of all of the numbers for the islands of Murano. We used these numbers in the construction of our other codes.

Isola (Island)	Codice (Code)
Del Convento	202
Navagero	204
Sacca San Mattia	201
Sacca Serenella	205
San Donato	203
San Pietro	206
San Stefano	207

7.6.2. Building Codes (Codice Edificio)

The building codes, as described in Chapter 3, are derived form the island code, and a number generated from the north-south location of the building. A demonstration can be seen on the map below. The center (shown with a blue box) of the top glass manufacturer is farther north than the center of any other company shown. As such it is labeled as 202 (the island code) – 001 (the northern-most building). The next northern-most building is coded as 202-002. If in the future, a building is added between 202-001 and 202-002, it would be given the code 202-001.5.



To sum up the method for creating building codes, they are numbered sequentially from north to south and written as follows: "island code" + "-" + "building number."

7.6.3. Chimney Codes (Codice Camini)

The chimney codes just add one more number to the building codes. The numbers for the chimneys come directly from the architectural renderings. The codes for the chimneys are created by the following: "building code" + " –" + "chimney number" ("building code" = "island code" + "building number").

7.6.4. Pollutant Codes (Codice Inquinamento)

Codice Inquinamento (Pollution Code)	Nome Inquinamento –Italiano (Pollutant Name - Italian)	Nome Inquinamento -Inglese (Pollutant Name – English)
As-C	Composti dell'Arsenico	Compounds of arsenic
Ba	Bario	Barium
Ca	Calcio	Calcium
Cd-C	Composti del cadmio	Compounds of cadmium
Ce	Cerio	Cerium
CO	Monossido di carbonio	Carbon monoxide
Co-C	Cobalto e i suoi composti	Compounds of cobalt
Cr-C	Composti del cromo	Compounds of chromium
Cu	Rame	Copper
F-C	Fluoro e fluorurui	Fluorides
HFl	Acido fluoridrico	Hydrofluoric acid
Mn	Manganese	Manganese
Nd	Neodimio	Neodymium
Ni	Nichel	Nickel
NOx	Ossidi di azoto	Nitrous oxides
Pb	Piombo	Lead
PST	Particelle sospese totali	Particulates
Sb	Antimonio	Antimony
Se-C	Selenio e i suoi composti	Compounds of selenium
Si	Silice Cristallina	Crystalline silica
Sn	Stagno	Tin
SOx	Ossidi di zolfo	Sulfur oxides
VOC	Composti volatili organici	Volatile organic compounds

7.6.5. Furnace Codes

Furnaces are designated by constructing a code by the following system: "building code" + "-" + "letter for furnace type" + "furnace number." The letters used for furnace type and the type of furnace they represent are shown in the following table. In most instances, the furnace number was taken from the blueprints. If the blueprints did not number the furnaces, we assigned them numbers.

Letter Code	Description
F	Fusione
T	Tempera
M	Muffola
R	Riscaldamento

7.7. Appendix G –Database

Properties

Date Created:	7/4/00 10:21:32 AM	Def. Updatable:	True
Last Updated:	7/29/00 12:43:52 AM	OrderBy:	[CODICI ISTAT].CODICE_ISTAT
OrderByOn:	True	RecordCount:	24

Columns

Name	Type	Size
CODICE_ISTAT	Text	50
Descrizione	Text	255

Relationships

CODICI ISTATGENERALITA_AZIENDE

CODICI ISTAT			GENERALITA_AZIENDE
CODICE_ISTAT	1	∞	CODICI_ISTAT

Attributes:	Enforced
Attributes:	One-To-Many

Table Indexes

Name	Number of Fields
CODICI ISTATCODICE_ISTAT	1
Fields:	CODICE_ISTAT, Ascending
PrimaryKey	1
Fields:	CODICE_ISTAT, Ascending

Properties

Date Created:	7/4/00 10:56:34 AM	Def. Updatable:	True
Last Updated:	7/29/00 12:52:44 AM	OrderByOn:	False
RecordCount:	61		

Columns

Name	Type	Size
CODICE_EDIFICIO	Text	10
CODICE_FOSSA	Text	15
TIPO	Text	20
N_PROTCOLLO	Text	15
DATA	Date/Time	8
RELAZIONE_TECNICA	Yes/No	1
VASCA DECANTAZIONE	Yes/No	1
FOSSA SETTICA	Yes/No	1
SCARICO_CIVILE	Yes/No	1
LUNGHEZZA	Number (Long)	4
LARGHEZZA	Number (Long)	4
ALTEZZA	Number (Long)	4
PROFONDITA	Number (Long)	4
ISPEZIONABILE	Yes/No	1
DIAMETRO_ENTRATA	Number (Long)	4
DIAMETRO_USCITA	Number (Long)	4
CODICE_AZIENDA	Text	6
CODICE_STAB	Text	10

Relationships

GENERALITA_EDIFICIOFOSSE

GENERALITA_EDIFICIO			FOSSE
CODICE_EDIFICIO	1	∞	CODICE_EDIFICIO

Attributes:	Enforced
Attributes:	One-To-Many

Table Indexes

Name	Number of Fields
FOSSECODICE_EDIFICIO	1
Fields:	CODICE_EDIFICIO, Ascending
GENERALITA_EDIFICIOFOSSE	1
Fields:	CODICE_EDIFICIO, Ascending

PrimaryKey	1
Fields:	CODICE_FOSSA, Ascending

Properties

Date Created:	7/4/00 10:38:49 AM	Def. Updatable:	True
Last Updated:	7/29/00 12:51:00 AM	OrderBy:	FUMI_AUTORIZZATI.CODICE_CAMINO
OrderByOn:	True	RecordCount:	438

Columns

Name	Type	Size
CODICE_AZIENDA	Text	6
CODICE_EDIFICIO	Text	10
CODICE_STAB	Text	10
CODICE_CAMINO	Text	15
CODICE_INQUI	Text	6
TEM_FUMI	Number (Double)	8
PORT_FUMI	Number (Double)	8
DUR_EMIS	Number (Double)	8
CON_LEG	Number (Double)	8
gr_h_LEG	Number (Double)	8
kg_anno_LEG	Number (Double)	8
MAPINFO_ID	Number (Long)	4

Relationships

GENERALITA_CAMINIFUMI_AUTORIZZATI

GENERALITA_CAMINI	**FUMI_AUTORIZZATI**
CODICE_CAMINO	CODICE_CAMINO

Attributes: Not Enforced
Attributes: One-To-Many

GENERALITA_EDIFICIOFUMI_AUTORIZZATI

GENERALITA_EDIFICIO	**FUMI_AUTORIZZATI**
CODICE_EDIFICIO	CODICE_EDIFICIO

Attributes: Not Enforced
Attributes: One-To-Many

GENERALITA_INQUINAMENTOFUMI_AUTORIZZATI

GENERALITA_INQUINAME	**FUMI_AUTORIZZATI**
CODICE_INQU	CODICE_INQUI

Attributes:	Not Enforced, Right Join
Attributes:	One-To-Many

Table Indexes

Name	Number of Fields
FUMI_AUTORIZZATICODICE_EDIFICIO	1
Fields:	CODICE_EDIFICIO, Ascending
GENERALITA_FUMICODICE_CAMINO	1
Fields:	CODICE_CAMINO, Ascending
MI_INDEX_FIELD	1
Fields:	MAPINFO_ID, Ascending

Properties

Date Created:	7/4/00 10:39:04 AM	Def. Updatable:	True
Last Updated:	7/16/00 10:53:33 PM	OrderByOn:	False
RecordCount:	0		

Columns

Name	Type	Size
CODICE_AZIENDA	Text	6
CODICE_EDIFICIO	Text	10
CODICE_STAB	Text	10
CODICE_CAMINO	Text	15
CODICE_INQUI	Text	6
DATA_MISURE	Date/Time	8
TEM_FUMI	Number (Double)	8
PORT_FUMI	Number (Double)	8
DUR_EMIS	Number (Double)	8
CON_CAMI	Number (Double)	8
gr_h_ACT	Number (Double)	8
kg_anno_ACT	Number (Double)	8

Relationships

GENERALITA_CAMINIFUMI_MISURATI

GENERALITA_CAMINI	**FUMI_MISURATI**
CODICE_CAMINO	CODICE_CAMINO

Attributes:	Not Enforced
Attributes:	One-To-Many

GENERALITA_INQUINAMENTOFUMI_MISURATI

GENERALITA_INQUINAME	**FUMI_MISURATI**
CODICE_INQU	CODICE_INQUI

Attributes:	Not Enforced, Right Join
Attributes:	One-To-Many

Table Indexes

Name	Number of Fields
GENERALITA_FUMICODICE_CAMINO	1

	Fields:	CODICE_CAMINO, Ascending
PrimaryKey		2
	Fields:	CODICE_CAMINO, Ascending
		CODICE_INQUI, Ascending

Properties

Date Created:	7/3/00 3:12:42 PM	Def. Updatable:	True
Last Updated:	7/29/00 12:44:38 AM	OrderBy:	GENERALITA_AZIENDE.CODICE_AZIENDA
OrderByOn:	True	RecordCount:	85

Columns

Name	Type	Size
CODICE_AZIENDA	Text	10
NOME_RAGIONE	Text	200
CODICI_ISTAT	Text	50
VIA_CALLE	Text	75
CIVICO	Text	5
LETTERA_CIVICO	Text	5
LOCALITA	Text	15
CAP	Number (Long)	4
TELEFONO	Text	15
FAX	Text	15
EMAIL	Text	50
WEB	Text	50
FIRMATARIA	Yes/No	1
RAPPRESENTANTE	Text	50
MAPINFO_ID	Number (Long)	4
CODICE_MAPA	Text	10

Relationships

CODICI ISTATGENERALITA_AZIENDE

CODICI ISTAT			GENERALITA_AZIENDE
CODICE_ISTAT	1	∞	CODICI_ISTAT

Attributes: Enforced
Attributes: One-To-Many

GENERALITA_AZIENDEGENERALITA_EDIFICIO

GENERALITA_AZIENDE	GENERALITA_EDIFICIO
CODICE_AZIENDA	CODICE_AZIENDA

Attributes: Not Enforced
Attributes: One-To-Many

GENERALITA_AZIENDEGENERALITA_STABILIMENTO

GENERALITA_AZIENDE			**GENERALITA_STABILIME**
CODICE_AZIENDA	1	∞	CODICE_AZIENDA

Attributes: Enforced
Attributes: One-To-Many

Table Indexes

Name	Number of Fields
CODICI ISTATGENERALITA_AZIENDE	1
Fields:	CODICI_ISTAT, Ascending
GENERALITA_AZIENDECODICE_AZIENDA	1
Fields:	CODICE_AZIENDA, Ascending
MI_INDEX_FIELD	1
Fields:	MAPINFO_ID, Ascending
PrimaryKey	1
Fields:	CODICE_AZIENDA, Ascending

Properties

Date Created:	7/3/00 3:16:44 PM	Def. Updatable:	True
Last Updated:	7/29/00 12:44:59 AM	OrderByOn:	False
RecordCount:	106		

Columns

Name	Type	Size
CODICE_AZIENDA	Text	6
CODICE_EDIFICIO	Text	10
CODICE_STAB	Text	10
CODICE_CAMINO	Text	15
ALTEZZA	Number (Double)	8
SUPF	Number (Double)	8
VERT_ORIZZ	Yes/No	1

Relationships

GENERALITA_CAMINIFUMI_AUTORIZZATI

GENERALITA_CAMINI	**FUMI_AUTORIZZATI**
CODICE_CAMINO	CODICE_CAMINO

Attributes: Not Enforced
Attributes: One-To-Many

GENERALITA_CAMINIFUMI_MISURATI

GENERALITA_CAMINI	**FUMI_MISURATI**
CODICE_CAMINO	CODICE_CAMINO

Attributes: Not Enforced
Attributes: One-To-Many

GENERALITA_EDIFICIOGENERALITA_CAMINI

GENERALITA_EDIFICIO			**GENERALITA_CAMINI**
CODICE_EDIFICIO	1	∞	CODICE_EDIFICIO

Attributes: Enforced
Attributes: One-To-Many

Table Indexes

Name	Number of Fields
GENERALITA_CAMINICODICE_CAMINO	1
Fields:	CODICE_CAMINO, Ascending
GENERALITA_EDIFICIOGENERALITA_CAM	1
Fields:	CODICE_EDIFICIO, Ascending
PrimaryKey	1
Fields:	CODICE_CAMINO, Ascending

Properties

Date Created:	7/3/00 3:09:16 PM	Def. Updatable:	True
Last Updated:	7/29/00 12:53:20 AM	OrderBy:	GENERALITA_EDIFICIO.CODICE_EDIFICIO
OrderByOn:	True	RecordCount:	172

Columns

Name	Type	Size
CODICE_EDIFICIO	Text	10
CODICE_AZIENDA	Text	6
CODICE_STABILIMENTO	Text	10
VIA_CALLE	Text	75
CIVICO	Text	5
LETTERA CIVICO	Text	5
AREA_TOTALE	Number (Long)	4
AREA_SCOPERTA	Number (Long)	4
AREA_COPERTA	Number (Long)	4
N_CAMINI	Number (Long)	4
N_FOSSE	Number (Long)	4
MAPINFO_ID	Number (Long)	4
CODICE_MAPA	Text	3

Relationships

GENERALITA_AZIENDEGENERALITA_EDIFICIO

GENERALITA_AZIENDE		**GENERALITA_EDIFICIO**
CODICE_AZIENDA		CODICE_AZIENDA

Attributes: Not Enforced
Attributes: One-To-Many

GENERALITA_EDIFICIOFOSSE

GENERALITA_EDIFICIO		**FOSSE**
CODICE_EDIFICIO	1 ∞	CODICE_EDIFICIO

Attributes: Enforced
Attributes: One-To-Many

GENERALITA_EDIFICIOFUMI_AUTORIZZATI

GENERALITA_EDIFICIO			FUMI_AUTORIZZATI
CODICE_EDIFICIO			CODICE_EDIFICIO

Attributes: Not Enforced
Attributes: One-To-Many

GENERALITA_EDIFICIOGENERALITA_CAMINI

GENERALITA_EDIFICIO			GENERALITA_CAMINI
CODICE_EDIFICIO	1	∞	CODICE_EDIFICIO

Attributes: Enforced
Attributes: One-To-Many

GENERALITA_EDIFICIOGENERALITA_FORNACE

GENERALITA_EDIFICIO			GENERALITA_FORNACE
CODICE_EDIFICIO	1	∞	CODICE_EDIFICIO

Attributes: Enforced
Attributes: One-To-Many

GENERALITA_STABILIMENTOGENERALITA_EDIFICIO

GENERALITA_STABILIME			GENERALITA_EDIFICIO
CODICE_STABILIMENTO	1	∞	CODICE_STABILIMENTO

Attributes: Enforced
Attributes: One-To-Many

Table Indexes

Name		Number of Fields
GENERALITA_EDIFICIOCODICE_AZIENDA		1
Fields:	CODICE_AZIENDA, Ascending	
GENERALITA_EDIFICIOCODICE_STAB		1
Fields:	CODICE_STABILIMENTO, Ascending	
GENERALITA_STABILIMENTOGENERALIT		1
Fields:	CODICE_STABILIMENTO, Ascending	
MI_INDEX_FIELD		1

Fields:	MAPINFO_ID, Ascending
PrimaryKey	1
Fields:	CODICE_EDIFICIO, Ascending

Properties

Date Created:	7/19/00 1:25:04 AM	Def. Updatable:	True
Last Updated:	7/29/00 12:53:20 AM	OrderBy:	GENERALITA_FORNACE.CODICE_FORNACE
OrderByOn:	True	RecordCount:	188
RowHeight:	255		

Columns

Name	Type	Size
CODICE_EDIFICIO	Text	10
CODICE_FORNACE	Text	15
TIPO_di_FORNACE	Text	30
CODICE_STAB	Text	10

Relationships

GENERALITA_EDIFICIOGENERALITA_FORNACE

GENERALITA_EDIFICIO			**GENERALITA_FORNACE**
CODICE_EDIFICIO	1	∞	CODICE_EDIFICIO

Attributes: Enforced
Attributes: One-To-Many

Table Indexes

Name	Number of Fields
GENERALITA_EDIFICIOGENERALITA_FOR1	
Fields:	CODICE_EDIFICIO, Ascending
GENERALITA_FORNACECODICE_EDIFICIO	1
Fields:	CODICE_EDIFICIO, Ascending

Properties

Date Created:	6/13/00 11:52:07 AM	Def. Updatable:	True
Last Updated:	7/16/00 10:59:39 PM	OrderByOn:	False
RecordCount:	22		

Columns

Name	Type	Size
CODICE_INQU	Text	6
NUM_INQU	Number (Long)	4
NOME_INQU	Text	50
PATOGENICITA'	Text	255
EVENTUALE_N_EQ	Text	50

Relationships

GENERALITA_INQUINAMENTOFUMI_AUTORIZZATI

GENERALITA_INQUINAME	**FUMI_AUTORIZZATI**
CODICE_INQU	CODICE_INQUI

Attributes: Not Enforced, Right Join
Attributes: One-To-Many

GENERALITA_INQUINAMENTOFUMI_MISURATI

GENERALITA_INQUINAME	**FUMI_MISURATI**
CODICE_INQU	CODICE_INQUI

Attributes: Not Enforced, Right Join
Attributes: One-To-Many

Table Indexes

Name	Number of Fields
Pollutant Code	2
Fields:	CODICE_INQU, Ascending
	NUM_INQU, Ascending
Pollution ListPollutant Code	1
Fields:	CODICE_INQU, Ascending
PrimaryKey	1
Fields:	CODICE_INQU, Ascending

Properties

Date Created:	6/29/00 11:00:49 AM	Def. Updatable:	True
Last Updated:	7/29/00 12:44:38 AM	OrderBy:	GENERALITA_STABILIMENTO.CODICE_AZIENDA
OrderByOn:	True	RecordCount:	156

Columns

Name	Type	Size
CODICE_AZIENDA	Text	6
CODICE_STABILIMENTO	Text	10
ATTIVITA	Text	50
CODICE_ISTAT	Text	10
DESCRIZIONE_ATTIVITA	Text	50
ACQUA	Number (Long)	4
LUCE	Number (Long)	4
GAS	Number (Long)	4
N_FORNI	Text	5
N_CROGIUOLI	Number (Long)	4
N_MOLE	Number (Long)	4
N_CAMINI	Number (Long)	4
N_FOSSE	Number (Long)	4
MAPINFO_ID	Number (Long)	4

Relationships

GENERALITA_AZIENDEGENERALITA_STABILIMENTO

GENERALITA_AZIENDE			GENERALITA_STABILIME
CODICE_AZIENDA	1	∞	CODICE_AZIENDA

Attributes: Enforced
Attributes: One-To-Many

GENERALITA_STABILIMENTOGENERALITA_EDIFICIO

GENERALITA_STABILIME			GENERALITA_EDIFICIO
CODICE_STABILIMENTO	1	∞	CODICE_STABILIMENTO

Attributes: Enforced
Attributes: One-To-Many

Table Indexes

Name	Number of Fields
GENERALITA_AZIENDEGENERALITA_STA	1
Fields:	CODICE_AZIENDA, Ascending
GENERALITA_STABILIMENTOCODICE_AZI	1
Fields:	CODICE_AZIENDA, Ascending
GENERALITA_STABILIMENTOCODICE_IST	1
Fields:	CODICE_ISTAT, Ascending
MI_INDEX_FIELD	1
Fields:	MAPINFO_ID, Ascending
PrimaryKey	1
Fields:	CODICE_STABILIMENTO, Ascending

Properties

Date Created:	6/27/00 3:43:19 PM	Def. Updatable:	True
Last Updated:	7/28/00 11:11:17 AM	OrderByOn:	True
RecordCount:	74		

Columns

Name	Type	Size
Sample Area Code	Text	50
Hg	Number (Double)	8
Cd	Number (Double)	8
Pb	Number (Double)	8
As	Number (Double)	8
Cr	Number (Double)	8
Cu	Number (Double)	8
Ni	Number (Double)	8
Zn	Number (Double)	8
Idr Tot	Number (Double)	8
IPA	Number (Double)	8
PCB	Number (Double)	8
Pesticidi	Number (Double)	8
Classificazione	Text	1
MAPINFO_ID	Number (Long)	4

Table Indexes

Name	Number of Fields
Idr Tot	1
Fields:	Idr Tot, Ascending
MI_INDEX_FIELD	1
Fields:	MAPINFO_ID, Ascending
Sample Area Code	1
Fields:	Sample Area Code, Ascending

Properties

Date Created:	6/13/00 12:02:25 PM	Def. Updatable:	True
Last Updated:	7/28/00 11:41:04 AM	OrderByOn:	False
RecordCount:	0		

Columns

Name	Type	Size
CODICE_SITO	Text	50
Date Taken	Date/Time	8
Time Taken	Date/Time	8
Decibel Level	Number (Long)	4
Blank Noise Level	Number (Long)	4

Properties

Date Created:	7/24/00 2:27:42 AM	Def. Updatable:	True
Last Updated:	7/28/00 11:32:45 AM	OrderByOn:	False
RecordCount:	172		

Columns

Name	Type	Size
MAPINFO_ID	Number (Long)	4
Codice_Ecologia	Text	4
Protocollo_Accordo	Text	8
Codice_ISTAT	Text	100
Codice_ISTAT_Secondario	Text	7
Firmataria	Yes/No	1
Rappresenative	Text	35
Nome_Ragione_Sociale	Text	180
Indirizzo	Text	200
Civico	Text	25
Lettera	Text	20
Ulteriore_Indirizzo	Text	100
Forni_Stimati	Text	5
Telefono	Text	50
Fax	Text	50
Area	Number (Double)	8
Perimetro	Number (Double)	8
Centroide_X	Number (Double)	8
Centroide_Y	Number (Double)	8
Etichetta	Text	30
Isola	Text	20
Codice_Isola	Text	4
Numero_Isola	Number (Long)	4
CAP	Number (Long)	4
CODICE_EDIFICIO	Text	10
CODICE_AZIENDA	Text	6

Table Indexes

Name	Number of Fields
primarykey	1
Fields:	MAPINFO_ID, Ascending

7.8. Appendix H – English Translation of Database

C:\WINDOWS\DESKTOP\MURANO ENGLISH.mdb — Friday, July 28, 2000
Table: Actual Air Emissions — Page: 1

Properties

Date Created:	7/4/00 10:39:04 AM	Def. Updatable:	True
Last Updated:	7/28/00 12:16:22 PM	OrderByOn:	False
RecordCount:	0		

Columns

Name	Type	Size
Business Code	Text	6
Building Code	Text	10
Establishment Code	Text	10
Chimney Code	Text	15
Pollutant Cde	Text	6
Date	Date/Time	8
Smoke Temperature	Number (Double)	8
Volume Smoke	Number (Double)	8
Duration of Emission	Number (Double)	8
Concentrtion	Number (Double)	8
grams per hour	Number (Double)	8
kg per year	Number (Double)	8

Table Indexes

Name	Number of Fields
GENERALITA_FUMICODICE_CAMINO	1
Fields:	Chimney Code, Ascending
PrimaryKey	2
Fields:	Chimney Code, Ascending Pollutant Cde, Ascending

Properties

Date Created:	7/18/00 6:11:41 PM	Def. Updatable:	True
Last Updated:	7/28/00 12:31:44 PM	OrderByOn:	False
RecordCount:	106		

Columns

Name	Type	Size
Chimney Code	Text	15
As-C	Number (Double)	8
Ba	Number (Double)	8
Ca	Number (Double)	8
Cd-C	Number (Double)	8
Ce	Number (Double)	8
CO	Number (Double)	8
Co-C	Number (Double)	8
Cr	Number (Double)	8
Cu	Number (Double)	8
F-C	Number (Double)	8
HFl	Number (Double)	8
Mn	Number (Double)	8
Nd	Number (Double)	8
Ni	Number (Double)	8
NOx	Number (Double)	8
Pb	Number (Double)	8
PST	Number (Double)	8
Sb	Number (Double)	8
Se	Number (Double)	8
Si	Number (Double)	8
Sn	Number (Double)	8
SOx	Number (Double)	8
VOC	Number (Double)	8

Properties

Date Created:	7/3/00 3:09:16 PM	Def. Updatable:	True
Last Updated:	7/28/00 12:18:50 PM	OrderByOn:	True
RecordCount:	172		

Columns

Name	Type	Size
Building Code	Text	10
Business Code	Text	6
Establishment Code	Text	10
Street	Text	75
Number	Text	5
Letter	Text	5
Total Area	Number (Long)	4
Open Area	Number (Long)	4
Covered Area	Number (Long)	4
No Chimneys	Number (Long)	4
No Settling Tanks	Number (Long)	4
MAPINFO_ID	Number (Long)	4
Map Code	Text	3

Table Indexes

Name	Number of Fields
GENERALITA_EDIFICIOCODICE_AZIENDA	1
Fields:	Business Code, Ascending
GENERALITA_EDIFICIOCODICE_STAB	1
Fields:	Establishment Code, Ascending
MI_INDEX_FIELD	1
Fields:	MAPINFO_ID, Ascending
PrimaryKey	1
Fields:	Building Code, Ascending

Properties

Date Created:	7/3/00 3:12:42 PM	Def. Updatable:	True
Last Updated:	7/28/00 12:19:47 PM	OrderByOn:	True
RecordCount:	85		

Columns

Name	Type	Size
Business Code	Text	10
Legal Name	Text	200
ISTAT Code	Text	50
Street	Text	75
Number	Text	5
Letter	Text	5
Locality	Text	15
Zip Code	Number (Long)	4
Telephone	Text	15
FAX	Text	15
EMAIL	Text	50
WEB	Text	50
Sign Accord	Yes/No	1
Representative	Text	50
MAPINFO_ID	Number (Long)	4
Map Code	Text	10

Table Indexes

Name	Number of Fields
GENERALITA_AZIENDECODICE_AZIENDA	1
Fields:	Business Code, Ascending
MI_INDEX_FIELD	1
Fields:	MAPINFO_ID, Ascending
PrimaryKey	1
Fields:	Business Code, Ascending

Properties

Date Created:	7/3/00 3:16:44 PM	Def. Updatable:	True
Last Updated:	7/28/00 12:20:35 PM	OrderByOn:	False
RecordCount:	106		

Columns

Name	Type	Size
Business Code	Text	6
Building Code	Text	10
Establishment Code	Text	10
Chimney Code	Text	15
Height	Number (Double)	8
Area	Number (Double)	8
Vertical or Horizontal	Yes/No	1

Table Indexes

Name	Number of Fields
GENERALITA_CAMINICODICE_CAMINO	1
Fields:	Chimney Code, Ascending
PrimaryKey	1
Fields:	Chimney Code, Ascending

Properties

Date Created:	6/29/00 11:00:49 AM	Def. Updatable:	True
Last Updated:	7/28/00 12:22:50 PM	OrderByOn:	True
RecordCount:	156		

Columns

Name	Type	Size
Building Code	Text	6
Establishment Code	Text	10
Activity	Text	50
ISTAT Code	Text	10
Description of ISTAT	Text	50
Water per year	Number (Long)	4
Electricity per year	Number (Long)	4
Gas per year	Number (Long)	4
No Furnaces	Text	5
No Melting Furnaces	Number (Long)	4
No Grinders	Number (Long)	4
No Chimneys	Number (Long)	4
No Settling Tanks	Number (Long)	4
MAPINFO_ID	Number (Long)	4

Table Indexes

Name	Number of Fields
GENERALITA_STABILIMENTOCODICE_AZI1	
Fields:	Building Code, Ascending
GENERALITA_STABILIMENTOCODICE_IST1	
Fields:	ISTAT Code, Ascending
MI_INDEX_FIELD	1
Fields:	MAPINFO_ID, Ascending
PrimaryKey	1
Fields:	Establishment Code, Ascending

Properties

Date Created:	7/19/00 1:25:04 AM	Def. Updatable:	True
Last Updated:	7/28/00 12:23:17 PM	OrderByOn:	True
RecordCount:	188	RowHeight:	255

Columns

Name	Type	Size
Building Code	Text	10
Furnace Code	Text	15
Type of Furnace	Text	30
Establishment Code	Text	10

Properties

Date Created:	6/13/00 11:52:07 AM	Def. Updatable:	True
Last Updated:	7/28/00 12:24:05 PM	OrderByOn:	False
RecordCount:	22		

Columns

Name	Type	Size
Pollutant Code	Text	6
NUM_INQU	Number (Long)	4
Pollutant Name	Text	50
Toxicity	Text	255
EVENTUALE_N_EQ	Text	50

Table Indexes

Name	Number of Fields
Pollutant Code	2
Fields:	Pollutant Code, Ascending
	NUM_INQU, Ascending
Pollution ListPollutant Code	1
Fields:	Pollutant Code, Ascending
PrimaryKey	1
Fields:	Pollutant Code, Ascending

Properties

Date Created:	7/4/00 10:21:32 AM	Def. Updatable:	True
Last Updated:	7/28/00 12:24:20 PM	OrderByOn:	True
RecordCount:	24		

Columns

Name	Type	Size
ISTAT Code	Text	50
Description	Text	255

Table Indexes

Name	Number of Fields
CODICI ISTATCODICE_ISTAT	1
Fields:	ISTAT Code, Ascending
PrimaryKey	1
Fields:	ISTAT Code, Ascending

Properties

Date Created:	6/13/00 12:02:25 PM	Def. Updatable:	True
Last Updated:	7/28/00 12:24:29 PM	OrderByOn:	False
RecordCount:	0		

Columns

Name	Type	Size
Site Code	Text	50
Date Taken	Date/Time	8
Time Taken	Date/Time	8
Decibel Level	Number (Long)	4
Blank Noise Level	Number (Long)	4

Properties

Date Created:	6/27/00 3:43:19 PM	Def. Updatable:	True
Last Updated:	7/28/00 12:25:48 PM	OrderByOn:	True
RecordCount:	74		

Columns

Name	Type	Size
Sample Area Code	Text	50
Hg	Number (Double)	8
Cd	Number (Double)	8
Pb	Number (Double)	8
As	Number (Double)	8
Cr	Number (Double)	8
Cu	Number (Double)	8
Ni	Number (Double)	8
Zn	Number (Double)	8
Total Hydrocarbon	Number (Double)	8
Aromatic Hydrocarbon	Number (Double)	8
PCB	Number (Double)	8
Pesticides	Number (Double)	8
Classification	Text	1
MAPINFO_ID	Number (Long)	4

Table Indexes

Name	Number of Fields
Idr Tot	1
Fields:	Total Hydrocarbon, Ascending
MI_INDEX_FIELD	1
Fields:	MAPINFO_ID, Ascending
Sample Area Code	1
Fields:	Sample Area Code, Ascending

Properties

Date Created:	7/4/00 10:56:34 AM	Def. Updatable:	True
Last Updated:	7/28/00 12:27:53 PM	OrderByOn:	False
RecordCount:	61		

Columns

Name	Type	Size
Building Code	Text	10
Tank Code	Text	15
Type	Text	20
Protocoll Number	Text	15
Date	Date/Time	8
Technical Information	Yes/No	1
Decanting Tankk	Yes/No	1
Settling Tank	Yes/No	1
Type of waste	Yes/No	1
Length	Number (Long)	4
Width	Number (Long)	4
Heighth	Number (Long)	4
Depth	Number (Long)	4
Inspectable	Yes/No	1
Entrance Diameter	Number (Long)	4
Exit Diameter	Number (Long)	4
Business Code	Text	6
Establishmnet Code	Text	10

Table Indexes

Name	Number of Fields
PrimaryKey	1
Fields:	Tank Code, Ascending

Properties

Date Created:	7/24/00 2:27:42 AM	Def. Updatable:	True
Last Updated:	7/28/00 12:30:01 PM	OrderByOn:	False
RecordCount:	172		

Columns

Name	Type	Size
MAPINFO_ID	Number (Long)	4
Ecologia Code	Text	4
Accord Code	Text	8
ISTAT Code	Text	100
Secondary ISTAT Code	Text	7
Sign the Accord	Yes/No	1
Representative	Text	35
Legal Name	Text	180
Street	Text	200
Number	Text	25
Letter	Text	20
Furnace Address	Text	100
Estimated Furnaces	Text	5
Telephone	Text	50
Fax	Text	50
Area	Number (Double)	8
Perimeter	Number (Double)	8
Centroid_X	Number (Double)	8
Centroid_Y	Number (Double)	8
Labels	Text	30
Island	Text	20
Island Code	Text	4
Island Number	Number (Long)	4
Zip Code	Number (Long)	4
Building Code	Text	10
Business Code	Text	6

Table Indexes

Name	Number of Fields
primarykey	1
Fields:	MAPINFO_ID, Ascending

7.9. Appendix I - Sample MSDS[54]

```
HARPA HF -- HORPUSILKI
MATERIAL SAFETY DATA SHEET
NSN: 801000N019853
Manufacturer's CAGE: HARPA
Part No. Indicator: A
Part Number/Trade Name: HORPUSILKI
===========================================================================
                           General Information
===========================================================================
Company's Name: HARPA HF
Company's Street: STORHOFOA 44
Company's City: 132 REYKJAVIK
Company's Country: IC
Company's Emerg Ph #: 91-674400
Company's Info Ph #: 91-674400
Record No. For Safety Entry: 001
Tot Safety Entries This Stk#: 001
Status: SMJ
Date MSDS Prepared: 05FEB91
Safety Data Review Date: 21OCT91
MSDS Serial Number: BLVJT
Hazard Characteristic Code: F8
===========================================================================
                     Ingredients/Identity Information
===========================================================================
Proprietary: NO
Ingredient: WHITE SPIRIT
Ingredient Sequence Number: 01
NIOSH (RTECS) Number: ZC3850000
OSHA PEL: NOT APPLICABLE
ACGIH TLV: 100 PPM (MFR)
===========================================================================
                     Physical/Chemical Characteristics
===========================================================================
Appearance And Odor: OPAQUE LIQUID WITH MILD ODOR
Boiling Point: 212F,100C
Vapor Density (Air=1): <1
Specific Gravity: 1.44
Evaporation Rate And Ref: >1
Solubility In Water: YES
===========================================================================
                      Fire and Explosion Hazard Data
===========================================================================
Flash Point: >194F,>90C
Extinguishing Media: DRY CHEMICAL OR FOAM.
Special Fire Fighting Proc: WATER MAY BE USED TO COOL AND PROTECT
CONTAINERS. WEAR NIOSH/MSHA APPROVED SCBA AND FULL PROTECTIVE EQUIPMENT (FP
N).
Unusual Fire And Expl Hazrds: CLOSED CONTAINERS MAY BURST IF EXPOSED TO
EXTREME HEAT OR FIRE.
===========================================================================
                              Reactivity Data
===========================================================================
```

[54] HARPA HF HORPUSILKI MSDS. http://msds.pdc.cornell.edu/msds/siri/msds/h/q170/q151.htm. (February 5, 1991).

Stability: YES
Cond To Avoid (Stability): ELEVATED TEMPERATURES AND FREEZING.
Materials To Avoid: ANY MATERIAL WHICH REACTS VIOLENTLY WITH WATER.
Hazardous Decomp Products: CO, CO2.
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): NOT RELEVANT.

Health Hazard Data

LD50-LC50 Mixture: NONE SPECIFIED BY MANUFACTURER.
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: YES
Health Haz Acute And Chronic: IRRITATION OF EYES, SKIN AND RESPIRATORY TRACT.
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NOT RELEVANT.
Signs/Symptoms Of Overexp: SEE HEALTH HAZARDS.
Med Cond Aggravated By Exp: NONE SPECIFIED BY MANUFACTURER.
Emergency/First Aid Proc: INHAL:REMOVE TO FRESH AIR. SKIN:WASH WITH SOAP & WATER. INGEST:DO NOT INDUCE VOMITING, GET MD. EYE:FLUSH WITH POTABLE WATER FOR A MINIMUM OF 15 MINUTES. GET MD (FP N).

Precautions for Safe Handling and Use

Steps If Matl Released/Spill: ADD ABSORBENT. TRANSFER TO APPROPRIATE CONTAINER. WASH WITH WATER.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Method: BRING TO LANDFILL, ACCORDING TO LOCAL, STATE, AND FEDERAL REGULATIONS.
Precautions-Handling/Storing: STORE BELOW 86F(30C), KEEP FROM FREEZING.
Other Precautions: KEEP OUT OF REACH OF CHILDREN.

Control Measures

Respiratory Protection: NIOSH/MSHA APPROVED VAPOR MASK.
Ventilation: LOCAL AND MECHANICAL (GENERAL) EXHAUST IS REQUIRED.
Protective Gloves: POLYETHYLENE GLOVES.
Eye Protection: CHEMICAL WORKERS GOGGLES (FP N).
Other Protective Equipment: NONE SPECIFIED BY MANUFACTURER.
Work Hygienic Practices: NONE SPECIFIED BY MANUFACTURER.
Suppl. Safety & Health Data: NONE SPECIFIED BY MANUFACTURER.

Transportation Data

Trans Data Review Date: 92043
DOT PSN Code: ZZZ
DOT Proper Shipping Name: NOT REGULATED BY THIS MODE OF TRANSPORTATION
IMO PSN Code: ZZZ
IMO Proper Shipping Name: NOT REGULATED FOR THIS MODE OF TRANSPORTATION
IATA PSN Code: ZZZ
IATA Proper Shipping Name: NOT REGULATED BY THIS MODE OF TRANSPORTATION
AFI PSN Code: ZZZ
AFI Prop. Shipping Name: NOT REGULATED BY THIS MODE OF TRANSPORTATION
Additional Trans Data: NOT REGULATED FOR TRANSPORTATION

Disposal Data

Label Data

```
================================================================================
Label Required: YES
Technical Review Date: 21OCT91
Label Date: 21OCT91
Label Status: G
Common Name: HORPUSILKI
Chronic Hazard: NO
Signal Word: WARNING!
Acute Health Hazard-None: X
Contact Hazard-Slight: X
Fire Hazard-Moderate: X
Reactivity Hazard-None: X
COMBUSTIBLE. MAY CAUSE EYE, SKIN AND RESPIRATORY TRACT IRRITATION. CHRONIC
EFFECTS:NONE LISTED BY MANUFACTURER.
Protect Eye: Y
Protect Skin: Y
Protect Respiratory: Y
Label Name: HARPA HF
Label Street: STORHOFOA 44
Label City: 132 REYKJAVIK
Label Country: IC
Label Emergency Number: 91-674400
```

More sample MSDS can be found at the same website, and any company selling chemicals should make them available for free. MSDS databases can be found on the World Wide Web as well.

7.10. Appendix J - Sample of Form

7.11. Appendix K – Health Effects of Metals Used to Color Glass[55]

Metal	Entry Routes	Points of Attack*	Effects*
Arsenic	Inhalation Ingestion	Respiratory System, Eyes, Skin	Corrosive Irritant Nausea Bloody Diarreha and Vomitting Shock Carcinogen – Lung, Skin
Chromium	Ingestion Eye and Skin Contact	Blood, Lungs, Liver, Respiratory System, Kidneys, Eyes, Skin	Corrosive Irritant Carcinogen – Lung
Cobalt	Inhalation Ingestion Eye and Skin Contact	Respiratory System, Lungs, Skin	Irritant Asthma Pneumonia
Copper	Inhalation Ingestion Eye and Skin Contact	Respiratory System, Lungs, Liver, Kidneys, Eyes, Skin	Irritant Nasal Congestion Nausea
Cadmium	Inhalation Ingestion	Respiratory System, Lungs, Kidneys, Prostrate, Blood	Pneumonia Anemia Emphysema Kidney Damage Carcinogen – Prostrate, Renal
Iron	Inhalation	Respiratory System, Lungs	Respiratory Irritant Lung Damage
Lead	Inhalation Ingestion Eye and Skin Contact	Kidneys, Blood, Gingival Tissue, Gastrointestinal System, Central Nervous System	Anemia Damage to Central Nervous System Kidney Damage
Manganese	Inhalation Ingestion	Respiratory System, Kidneys, Lungs, Blood, Central Nervous System	Irritant Severe Psychopathological
Mercury	Inhalation Ingestion Eye and Skin Contact	Respiratory System, Central Nervous System, Kidneys, Eyes, Skin	Irritant Pneumonia Psychopathological
Nickel	Inhalation Ingestion Eye and Skin Contact	Nasal Cavities, Lungs, Skin	Irritant Carcinogen – Lungs
Silver	Inhalation Ingestion Eye and Skin Contact	Nasal Cavities, Eyes, Skin	Corrosive Irritant Permanent Skin Discoloration
Tin	Inhalation Eye and Skin Contact	Respiratory System, Eyes, Skin	Irritant Pneumonia
Uranium	Inhalation Ingestion Eye and Skin Contact	Respiratory System, Blood, Liver, Lymphatic, Kidneys, Skin, Bone Marrow	Kidney damage Carcinogen – From Radiation

*Note: Some of the data is specific to certain compounds and not for all forms of the metal.

[55] Sittig, Marshall. Handbook of Toxic and Hazardous Chemicals and Carcinogens. Park Ridge, NJ: Noyes Publications, 1985.

7.12. Appendix L – Complete List of Glass Manufacturers

NOME_RAGIONE (Name)	VIA_CALLE (Street)	CIVICO (Number)	LETTERA_CIVICO (Letter)
3 Fiori SNC	Fond. Vetrai	109	a
A.V. Mazzega SRL	Calle Vivarini	3	b
Aldo Rossetto e C. di PG. e P. Rossetto	Calle del Cimitero	12	a
Alfio dalla Venezia Aventurina Vetro	Sacca Serenella	SM	
Andromeda SRL	Calle Miotti	16	
Anfora	Sacca Serenella	SM	
Antica Murano	Fond. Manin	1	
APA SRL	Calle de l'Artigiano	15	
ARS Murano SRL	Ramo San Giuseppe	7	
Artifex Vitri SRL	Fond. Radi	27	
Artigianato Muranese SNC	Calle Bertolini	39	
Artigianto Artistico Veneziano	Calle San Ciprano	2	a
Arto E. Nason	Fond. San Lorenzo	17	
Assivetro	Fond. S. Giovanni Battuti	4	d
AVEM Arte Vetreria Muranese SAS	Fond. Vetrai	33	
B. e D. Murano di Donà P. e C.	Corte Turella	4	a
Balbi	Ramo San Bernardo	6	d
Ballarin	Calle de le Conterie	23	
Barbini Alfredo SRL	Fond. Venier	44/48	
Barovier e Toso	Fond. Vetrai	27/28	
Berengo Fine Arts	Fond. Manin	1	
Berlese Massimilano	Sacca Serenella	SM	
Bielle di Cammozzo Bruno	Calle San Sagredo	1	
Bisazza Vetro SRL	Fond. Manin	40	
CAM Vetri d'Arte	Piazzale alla Colonna	1	b
Campagnol e Salvadore di Salvadore	Fond. Vetrai	122	a/b
Campanella Glass Piccola Societa SRL	Sacca Serenella	14	
Campanella Livio SNC	Ramo del Cimitero	6	
Cenedese Gino e Figlio	Fond. Venier	48	
CIVAM Fornace SRL	Bressagio	23	
CO. RO. Tre	Fond. Vetrai	10	
Compagnia Vetraria Muranese SRL	Fond. Manin	1	
Componenti Donà	Calle Vivarini	5	
Coop. Luigi Morassi Soc. Coop. ARL	Fond. Vetrai	14	
Cristal Center Factory in Murano SRL	Calle del Paradiso	66	
D'este Bruno	Fond. Venier	38	a
De Biasi Virgilio e C. SNC	Fond. Navagero	54	b

Di. Pi. Rossi Imperio	Calle San Cipriano	21	
Donà Gino	Calle Pescheria	7	b
Donà Guido	Fond. Vetrai	123	a
Effe Vetreria Artistica di Furlan D e C SAS	Fond. Navagero	54	
Effedi 3 Vetri di Formentello Francesco	Calle Giovanni della Casa	3	
Effedue di Franco Fuga	Fond. Vetrai	93	a
Effetre International SPA	Fond. Battuti	4	a
Eli Vetri d'Arte SNC	Fond. Manin	72/74	
Elite Murano SRL	Calle del Cimitero	6	
Ercole Moretti e fratelli	Fond. Navagero	42	
F.lli Zanchi SNC	Fond. S. Giovanni Battuti	4/5	
Fabbris e Ferro	Fond. Radi	25	
Ferro e Lazzarini SRL	Fond. Navagero	75	
Ferro Galliano	Fond. Vetrai	43	
Formia di Mian Alfio	Fond. Vetrai	138	
Fornasier Luigi di Fornasier Fabio e C. SNC	Calle del Paradiso	70	
Foscarini Murano SPA	Fond. Manin	3	
Fratelli Barbini di Barbini Cesare	Calle Bertolini	17	a
Fratelli Ferro di Fabris Gofredo	Fond. Vetrai	74	
Gambaro e Poggi SNC	Calle Vivarini	6	
Genedese e Gasparini SNC	Fond. Manin	1	a
Guarnieri Vetr. A.	Fond. Serenella	4	
Idea Murano SNC	Fond. Vetrai	148	
J.W.P. di Cavagnis	Calle Briati	3	
L'Artistica Muranese di Badioli M. e. C.	Fond. Vetrai	74	
L.I.P. SAS	Fond. Navagero	59	a
La Fornasotta do Urban Gabriele	Campo del Pra'	15	
La Fucina del Vetro	Fond. S. Giovanni Battuti	11	
La Murrina SRL	Fond. Cavour	17	a/b
Laboratorio Artigianale Balbi Claudia	Sacca Serenella	SM	
Laboratorio Lavorazione Vetro SNC	Calle dell'Artigiano	13	
Lavorazioni Artistiche di Amadi Fabiano	Fond. Venier	38	a
Line Arte Vetro	Fond. Venier	38	a
Linea Mazzuccato	Fond. Manin	1	
Linea Padovan	Calle Miotti	14	c
Linea Valentina di Dalla Valentina A.	Ramo Da Mula	177	
Linea Vetro di Cenedese C. e S.	Calle Bertolini	6	
Ma. Si. SNC	Ramo San Bernardo	6	d
Maestri Muranesi SRL	Sacca Serenella	21	
Maguse Cristalli	Fond. Venier	38	a
Mandruzzato Luigi di Gianfranco	Fond. Navagero	54	b

Mazzuccato di M. Daniele SRL	Ramo Da Mula	177	
Mazzuccato International	Fond. Manin	1	
Molatura e Intaglio	Ramo del Cimitero	7	
Moretti Carlo SRL	Fond. Manin	3	
Moretti Franco	Calle Bertolini	25	
Mosaici Donà	Fond. Venier	38	a
Murano Glass Company	Sacca Serenella	10	
N.O.R. Glass Factory SNC	Sacca Serenella	14	
Nason e Moretti SRL	Calle Dietro Gli Orti	12	
New Arte 90 SNC	Sacca Serenella	90	
Nuova Artigiana Colleoni SNC	Fond. S. Giovanni Battuti	12	
Nuova Marco Polo SRL	Fond. Manin	1	
Nuova PIM Cristalleria SAS	Calle del Paradiso	67	b
Ongaro Fuga di Fuga G. e C.	Calle del Cristo	17	
Padovan Alberto/Luigi	Sacca Serenella	SM	
Pagan Murrine di C. Pagan	Calle Moschini	17	
Pagnin di Pagnin Sergio	Campo Cimitero	4	
PMG Fratelli Pitau Vetreria Artistica	Calle Miotti	15	
Premiata Glass	Fond. Navagero	32	
Ragazzi e C. SNC	Ramo Da Mula	156	a
RCR di Rossetto Fabio e C. SNC	Ramo Beroviero	6	
S.D.F. di Smerghetto De Sanzuane	Fond. Navagero	54	b
SALIR di Toso e Mario D'Alpaos	Fond. Manin	77/78	
Salmistrari e Mazzega	Sacca Serenella	SM	
SAMEVA SAS	Fond. Vetrai	39/40	
Santi	Ramo Beroviero	5	g
Seguso Gianni	Fond. Serenella	3	
Seguso Viro SRL	Fond. Venier	29	
Sent di S. e M. Sent SNC	Calle de l'Ogio	1	
Sent Guglielmo di R. e P. Sent	Fond. Vetrai	8	a/b
Serena Giovanni di G. e M. Serena	Fond. Manin	69	c
Signoretti International SRL	Ramo San Cipriano	21	
Signoretto Lampadari SNC	Fond. Da Mula	148	
Signoretto Silvano	Calle Vivarini	6	
Striulli Vetri d'Arte	Calle dell'Artigiano	13	
Studio '86 Cristalleria art. Barovier A. e V. SNC	Fond. Radi	14	
SVA Soc. Vetraria Art. Oniga G. e C. SAS	Fond. Serenella	1	
Tagliapietra Alessandro	Fond. F. Colleoni	7	
Tagliapietra Dino	Calle del Supiador	10	
TFZ International SRL	Fond. Venier	38	a
Toso Aureliano	Fond. Radi	25	
Tre Emme	Ramo San Giuseppe	3	
VENINI SPA	Fond. Vetrai	50	

Vetr. Art. Archimede Seguso	Fond. Serenella	18	
Vetr. Art. Vivarini SRL	Fond. Serenella	5/6	
Vetreria Accaeffe	Fond. Radi	25	
Vetreria ai Dogi SNC	Bressagio	25	
Vetreria Antichi Angeli SAS	Calle S. Giuseppe	18	a
Vetreria Artigiana Fratelli Pagnin SNC	Campo Cimitero	4/5	
Vetreria Artigiana Nuova Biemmeci SAS	Fond. San Mattia	2	a
Vetreria Artistica Bortolotti e Rubelli SNC	Ramo Barovier	1	
Vetreria Artistica Colleoni SNC	Fond. S. Giovanni Battuti	12	
Vetreria Artistica Mazzucato Gaetano Gino	Fond. Manin	1	
Vetreria Artistica Oball SNC	Fond. Navagero	38	
Vetreria Artistica Schiavon	Fond. Vetrai	7	
Vetreria Ballarin	Campo San Bernardo	7	c
Vetreria Bisanzio SRL	Calle del Paradiso	67	
Vetreria Ca' D'Oro	Fond. Vetrai	8	
Vetreria D'Este Pacifico	Fond. Radi	14	b
Vetreria De Majo	Fond. Navagero	29	
Vetreria Ducale di Elena e Lino Messina SNC	Fond. Navagero	76	a
Vetreria La Fenice SNC	Fond. Da Mula	150	
Vetreria LAG	Fond. S. Santi	6	
Vetreria Murano Arte	Calle San Cipriano	48	
Vetreria Navagero	Fond. Navagero	59	a
Vetreria Pino Signoretto SNC	Fond. S. Giovanni Battuti	4	
Vetreria Rossetto Estevan SRL	Fond. Navagero	50	
Vetreria S. Angelo SRL	Fond. Radi	16	
Vetreria Studio Rosin SRL	Calle Pescheria	6	
Vetreria Toso Cesar di Toso E. e C.	Calle Vivarini	7	
Vetreria Venier di Cimoncin L.	Fond. Navagero	54	b
Vetretria 2001 SRL	Fond. S. Giovanni Battuti	4	d
Vianello SAS	Fond. S. Giovanni Battuti	4	d
Vincenzo Nason e C.	Calle Vivarini	16	
VMI Vetreria Murrine International di Lunetta Alessandra	Sacca Serenella	14	a
Z & R di Rossi Roberto	Fond. Colleoni	7	
Zanetti Vetreria Artistica	Fond. Serenella	3	
(Cessata Attivita)	Fond. Serenella	19/20	