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Traditional Arctic native fish storage methods and their role in the sustainable development of the Arctic

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Abstract The business of the Arctic has received increased attention owing to climate change. However, resource development and the use of waterways threaten the fragile Arctic ecology. The indigenous people of the Arctic have acquired a vast amount of traditional knowledge about coexisting in harmony with nature over the course of many years. Herein, five types of fish storage facilities that are commonly used by Arctic indigenous people and their working mechanisms are described. The traditional knowledge of the Arctic indigenous people is practically applied in Arctic fish storage systems, which are still common, effective, and environmentally friendly. The traditional fish storage facilities of the aborigines are of significance because they promote the sustainable development of the Arctic.

Keywords **fish storage facility, Arctic indigenous people, sustainable development, frozen soil, permafrost, fermented fish**

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1 Indigenous traditional knowledge and sustainable development

Indigenous people have lived in the Arctic region for more than 10000 years. Before the invasion of modern industrial civilization, the traditional knowledge of the indigenous peoples in the Arctic played a huge role in sustaining life. In the Arctic, resource use by the indigenes of the Arctic is sustainable and causes minimal pollution and there is no doubt about the sustainable development of the Arctic at that old time. Modern industrial civilization has brought challenges to the life of the indigenes in the Arctic. Traditional livelihoods are unsustainable right now, and sustainable development has become a new issue.

1.1 Tradition in harmony with nature

As pointed out in the book "Scientists and Global

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Governance", the indigenous people of the Arctic have a decisive say in the disposal of local resources while maintaining their right to live, lifestyle, and cultural traditions (Yang et al. 2018). The indigenous people of the Arctic have lived in harmony with nature and have mastered the development of a green economy for thousands of years. The natural harmony model is also a low carbon environmental model, and it has existed for thousands of years. Those who are involved in the current development of the Arctic must consider the sustainable development and environmental protection of the Arctic. Otherwise it will bring great damage to the Arctic environment.

1.2 Culture of ice and snow

The harsh climate conditions of the Arctic region include various low-temperature phenomena and processes. People have acquired specific skills with respect to the utilization of natural low-temperature resources (snow, ice, frozen soil) as natural preservatives, freshwater sources, and building materials (Melnikov, 2018).

Romanova & Dobzhanskaya (2019) points out that, "In modern science, permafrost is not only regarded as determining the conditions and culture of cold regions to a large extent. The natural phenomenon of life and lifestyle, and is regarded as the metaphor of all super-processes and super-beings. These super-processes and super-beings determine the existence of human beings. The cold is manifested as a multi-dimensional existence category, concept, metaphor, and image archetype. To a large extent, it has shaped the life world of the human community and individuals. The interdisciplinary paradigm of scientific issues can explore the cold phenomenon as a model for the formation of northern cities, explore new ways to construct a positive trajectory of northern identity, and use cold as permafrost creative resources and symbolic capital for regional development". This passage shows that cold is a resource, not a threat, in the indigenous culture of the Arctic. Ice and snow represent resources, wealth, and safety in the hearts of the Arctic indigenes.

1.3 Modernization of traditional knowledge

The traditional businesses of Arctic indigenous peoples include fishing, hunting, gathering, and raising reindeer. Fishing is particularly important. Arctic fish are rich in a variety of nutrients, which are important for the survival of the indigenous people in this harsh natural environment. Therefore, fish storage is very important and a unique traditional fish storage culture has formed. The Arctic indigenous fish storage facility makes full use of the frozen soil, ice and snow resources in the Arctic region, and is a model of green and sustainable economic development. At the same time, the rediscovery of the Arctic aboriginal ice and snow culture is also part of the modernization of traditional knowledge. The combination of utilizing ice and snow resources and modern freezing technologies are expected to contribute to the sustainable development of the Arctic.

2 Traditional facilities for fish storage

Fish has always been one of the key ingredients of the traditional diet of Arctic people. Fishery is an important part of the trade in the region. Therefore, people living in the Arctic region have a long history of using natural cryogenic resources to refrigerate fish. During the Soviet period, the original industrial-scale fish storage and transport methods were adopted in the Yamal–Nenets Autonomous Region, which also relied on the use of natural cryogenic resources. However, there is a lack of specialized research on this topic. We believe that information about these traditional methods may be very useful for the development of modern energy-efficient and environmentally sound industrial storage technologies in the Arctic region of the Russian Federation.

2.1 Pits for fermented fish

Hante, Nenets, Zyrian (Komi), and Russians living in the south of the Obska Guba, Obi downstream, and Nadym use shallow pit fermentation during the summer to preserve fish. Fish cooked based on this method are called salt fish and are considered to be a delicacy. Fish have a harsh, specific smell. The consumption of two or three salt fish can restore physical strength and bring a pleasant feeling of relaxation and warmth to the individual. The physiological function of salt fish significantly differs from that of raw or heat-treated fish, which might be due to the generation of microbial flora during fermentation (Lobanova, 2013).

Only fresh fish (i.e., those with a moving tail) are used to generate a salt fish mat. Near the mouth of the Ob River, the "black fish" ulcer and snapper are widely used. Only the best fish are selected. The scales and gills should be undamaged. The viscera are not removed.

To prepare a salt fish mat, a flat site with subclay and moderately wet soil, preferably with herbaceous plants, is selected. Swamps, flooded areas, and peatlands are not suitable. In acidic soil, fish over-soften, leading to a swampy flavor. Soil on mountaintops is too dry and is unsuitable because the sap enters the ground and the fish cannot be unearthed.

The turf layer of the salinized pit is removed and 50–60 cm deep pits are dug. Traditionally, there is a layer of sedge on the bottom and wall of the pit. Fish are stacked close to each other; generally, three rows of "heads and tails" are generated. The fish layers are marinated with coarse salt, and the sedges are distributed on each layer. Another layer of sedge is placed on top. The pit is then filled with soil and turf. The lid on the top is pressed tightly, and a board is used to cover at least 50 cm of the edge of the hole (to prevent Arctic foxes from entering through the hole).

The pit close to the mouth of the Ob River is 1 m deep and contains many layers of fish. The pit wall is reinforced with larch branches and coated with oily clay. Larch bark is placed at the bottom. The pit contains organic acids. The bones in the bottom of the fish soften, which is particularly important for marinating bony fish.

Permafrost and well-preheated pit covers are required to obtain quality salt fish. Permafrost prevents the rapid deterioration of the fish. In addition, water-resistant permafrost prevents saline fluid from flowing underground. At the interface of the frozen soil and thawing layers, the concentration of trace elements is always higher than that of the surface layer. As the old inhabitants stated, “fish must be soaked in mud juice”. These trace elements might be necessary for the development of microbial flora. The surface layer of the heated boards and pits is necessary to start the acidification of the fish. In August, the nights lengthen. The continuous heating of the surface layer stops, and the activity of the microbial flora decreases. The product then enters the mature stage.

It takes at least one month (generally 40 days) to prepare fillets. Fillets are prepared in August and early September. Ideally, the fish mat is placed in the pit 40 days before freezing. In September (after flies disappear), the mat is removed from the pit, wiped with peat moss, and dried on an outdoor rack. After the removal of the fish, the salinized pit is filled with soil. The pit can be reused after seven years. Locals prefer to prepare new pits every year.

In the northern part of the Gydan and Yamal peninsulas, the soil temperature is insufficient for the development of microbial flora capable of generating a gas well. Therefore, this type of storage is uncommon. In the south of the country, fish are marinated using enamel buckets. In the initial stages of fermentation, fish are fermented using a small amount of salt in open buckets. The buckets are then closed and buried in the ground for maturation (Figure 1).

Figure 1 Fermented fish (Habetayaha Encampment, Yamal).

2.2 Ice wells

A variety of frozen fish facilities are widely used by Russians and Zyrian (Komi) in the Arctic region of western Siberia. Glacier wells, which are widespread, are generally constructed in forests (long-term snow cover) or in areas with frozen soil. In general, locations close to rivers, that is, ice and fish, are preferred.

A well is dug to the required depth for up to a year in the frozen soil layer. The well depth generally does not exceed 3 m. The frozen soil gradually thaws and the well deepens. The shaft wall is reinforced with larch rod. Vertical support is important for frozen soil wells. When the frozen soil thaws, the horizontal incision sinks unevenly, which is difficult to repair. When the fixed parts of the glacial well are arranged vertically, they sink when the frozen soil thaws. To drain water, larch branches are used to pile up ice or dense snow in spring.

Generally, the well is filled with ice when it freezes; therefore, less effort is needed to maintain the usable area of the glacial well. Well owners who keep the wells low until autumn use winter ice because it does not melt for a long time. The ice is stacked as tightly as possible and sealed with a peat moss bag with low thermal conductivity. The well is sealed with poles, branches, old deer skins, or tarpaulins. Occasionally, a separate pit is created nearby to store ice and snow. In summer, the insulation is cleaned before the fish is removed. The ice is partially removed and placed on top of the fish, well fumigated with juniper or larch shavings. Bundles of slender birch branches are placed on the ice and the fish is stacked on top. Fish layers are created including ice chips that fill all gaps. The last layer has a pyramidal shape. The fish is covered with tarpaulin. The pyramids allow condensate and water to flow out of the canvas along the pit wall rather than through the stack of fish, which greatly increases the storage time of the fish. Pieces of ice are covered with tarpaulins. From the above facts, we can see that the glacier well is composed of ice, wooden boards, or branches. Some wells are covered by old deerskin (Figure 2).

Tents built using strong stumps, cabins, or sheds are usually constructed above the wells. These facilities help people to quickly locate wells, protect the wellhead from surface water pollution, slow down summer warming, and keep bears away (Figure 3).

In areas with abundant bears, the wellhead is sealed with a hedgehog, that is, a stake bundle with a blunt head. The beam itself is lowered into the well. The lower two ends

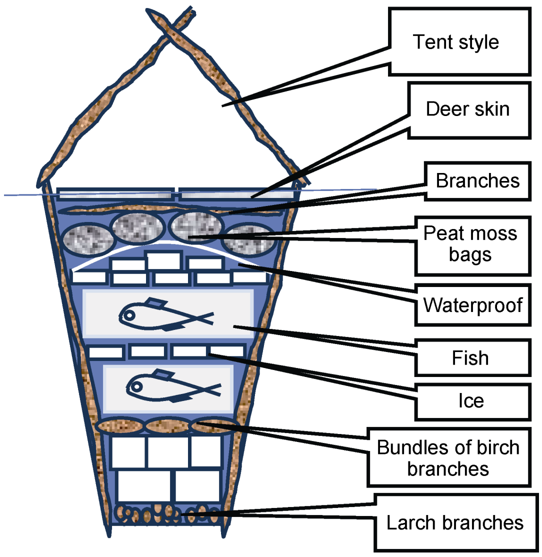

Figure 2 Structure of an ice well (Ivelovsky sand area, Nadym).

are connected. At the unconnected ends, the pile is fan-shaped. The goods are placed at the center of the generated "funnel lock," preventing the movement of the pile. Sometimes, the wooden poles of the hedgehog will be inserted into each other, reminiscent of a thistle flower. It is difficult for bears to overcome this obstacle, but people can easily move the goods, collect the stake bundles, and pull them out of the well (Figure 4).

Sometimes animal skins are used to cover the well burns. The smell of burned wool scares away bears and Arctic foxes. To scare away mice and voles, a layer of spruce branches is spread on the well.

In autumn, when the fish are removed from the well, the remaining ice cubes from the previous year are cleared. Bundles of branches are removed and placed over fire for sterilization and to prevent decay. In winter, the dry bundles are stacked vertically forming pyramids, similar to stacked wheat bundles. The water and mud that formed when the frozen soil thawed are removed and the support is adjusted.

Figure 3 Tent style on an ice well in Mouchi Village in 2006.

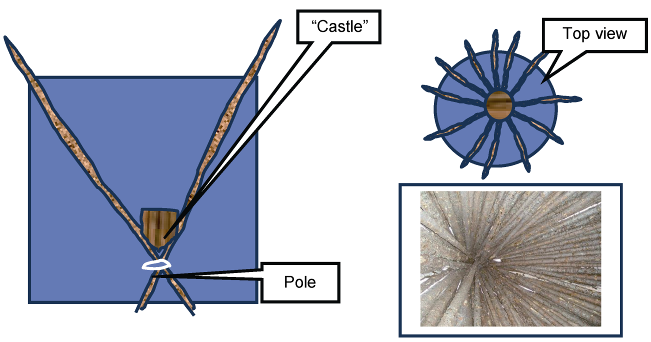

Figure 4 A 'hedgehog', i.e., a stake bundle with a blunt head.

To allow the wall to freeze, the well is kept open throughout the winter. Ice wells last for a long time. Wells close to the original Ivelovsky Pesky settlements along the lower reaches of the Nadym River date back to the early twentieth century.

In contrast to frozen soil, ice wells are not destroyed by ice flow because the wellbore is vertical. They accommodate more fish (because fish are compacted), do not require ventilation (because the denser cold air accumulates in wells due to gravity), and require less maintenance. However, fish do not freeze in ice wells. Because of the special microclimate, refrigerated fish can be preserved for up to one month without a reduction in their quality. This method is usually sufficient to store a batch of fish prior to transportation or processing to the quick-frozen equipment. Occasionally, wells are used to preserve the winter catch prior to shipping.

2.3 Ice cellars

Ice cellars are generally dug on the northern slopes of steep banks or gullies. The vault is reinforced with wooden pillars and sometimes boarded. The floor is covered with larch poles or logs. A drain at the bottom is filled with birch and larch bark, so that it cannot be blocked by dirt; this prevents a bad smell in the cellar. At the end of the trench, a pit is created for water. Along the cellar wall, two fences are built using boards. The boards are placed in grooves, which allows for the quick removal of the fence. This is necessary for the easy removal of the bucket. A cabin or plank porch is built in front of the cellar entrance. The fish are kept in buckets in the cellar and broken ice or thick spring snow is scattered between the buckets. Most cellars do not have ventilation ducts. To ensure ventilation, a window is installed at the top of the door. The porch is used to freeze fish in winter and store ice in spring.

Cellars are built next to the highway to provide readily available supplies and to simplify loading and unloading. They are mainly used for the storage of processed products, especially barreled salted fish. However, the food in cellars is not frozen (Figure 5).

Figure 5 Ice cellar (Highway 501).

2.4 Snow nest

Snow nests represent the simplest form of fish storage facility. They are mainly used to protect the spring fish population (Smelt, Chebak fish, Plum perch). In deep gullies on the southern coast of Obsk Bay, snow may last until mid-July, whereas it can be preserved until early August on the Gedana Peninsula. In general, snow accumulates in narrow gullies on the northern slopes of hills and riverbanks, creating a snow nest. A cave can then be constructed in the thick snow. The nests are then covered with tundra branches. The fish are stacked on top, covered with snow, and then covered with branches, peat, and moss. The top of the turf is covered with tarpaulins or old skins. Rain, rather than the sun, is the dominant factor causing the melting of snow in these regions. Therefore, the melting rate can be significantly reduced by protecting the snow from rain, even without a large amount of heat insulation. Although the design of the snow nest is simple, fish can be preserved for a month and even longer in a cold year.

2.5 Permafrost layer

Until the 1940s, people in the Arctic region of western Siberia used frozen wells, ice cellars, and snow to store fish. In summer, fish in such storage facilities is only cooled, but not frozen. Therefore, these facilities mainly store fish caught in winter, which freeze in the air. Winter-captured fish can be preserved in these storage facilities until summer shipping, but fresh fish captured in summer can neither be frozen nor stored for long periods. Instead, the fish are preserved in salt after removing the internal organs.

Before the construction of frozen soil areas, salted fish were transported by boat in barrels. This method increases transportation costs, because a small number of fish can be accommodated on board. In addition, the timely return, repair, and disposal of the barrels must be ensured. Remote factories often do not have sufficient manpower, buckets, or salt to process large quantities of fish. The collection and long-distance transportation of small quantities of fish by boat are low-profit practices. Before the establishment of frozen-soil storage, only the capture of beluga, white northern salmon, whitefish, pollan, and caviar was economically feasible. The development of frozen areas has significantly changed the fishing industry, making commercial fishing of all fish in the Yamal–Nenets Autonomous Region profitable and allowing for the long-distance transport of frozen fish.

Because of the ventilation system and frost heaving in permafrost, the temperature of the tunnel wall reaches –20 °C in winter. Thus, summer temperatures can be maintained between –9 and –12 °C (Figure 6). At this temperature, fish that have not been eviscerated will be frozen. Due to the significant increase in seasonal fishing in the summer, no workers relocate to process fish during the active fishing season. Fish that is frozen in the soil during summer can be transported in crates. For this purpose, the ship's cabin is stacked with ice and wooden fences. It is well known that punts are used to transport fish from Obi to Tobolsk, Akimeng, and even Omsk.

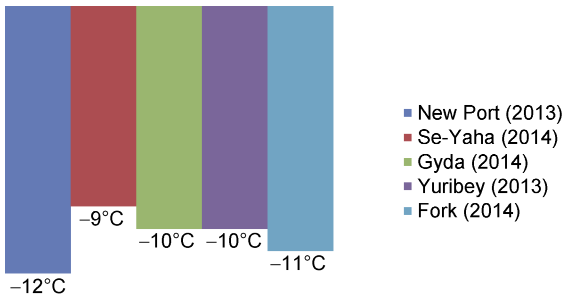

Figure 6 Indoor air temperature during permafrost (5–10 August).

Ice is also kept in frozen soil. Frozen soil has a complex structure. The main purpose of using frozen soil is the cold storage of products from winter to summer. A frozen tunnel wall can be realized via passive ventilation. The temperature difference and wind pressure at the entrance and exit of the frozen soil cellar can ensure sufficient air circulation (Figure 7).

For effective frozen soil storage, the selection of the construction location is very important. If the permafrost at the selected location is composed of a complete ice lens, the construction of the frozen soil will be easier. However, the operation of the tunnel is more difficult, and its height will decrease rapidly due to the flow of ice. Therefore, it is necessary to regularly deepen the vault of the tunnel. In addition, cold storage in frozen soil tunnels in ice lenses is more difficult than in sediment-rich frozen soil because the thermal conductivity of ice is lower than that of mineral inclusions. However, it is very time-consuming to construct a frozen soil layer in soil with abundant mineral particles.

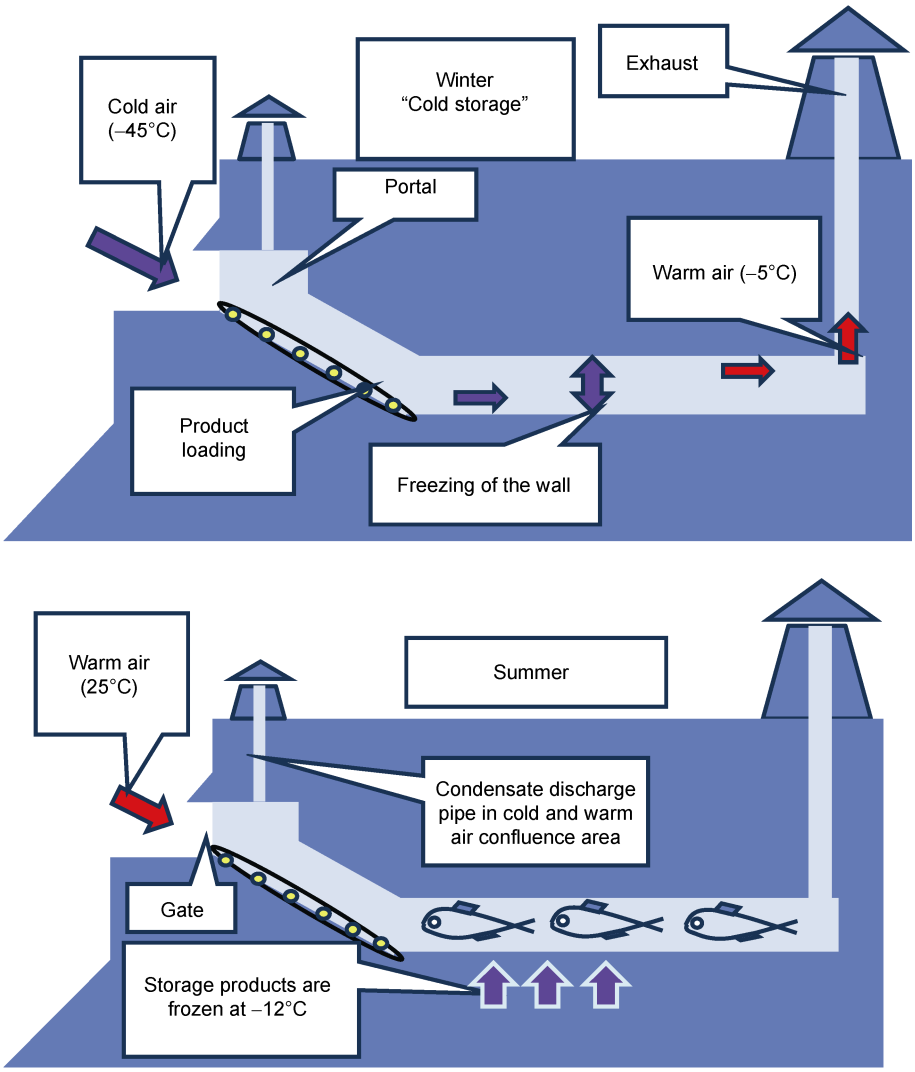

Figure 7 Layout and working principle of the frozen soil layer.

Thus, permafrost builders have tried to balance structural simplicity and durability, most commonly in homogeneous permafrost with high ice levels. They carefully check the freezing cracks, salt layers, and quicksand on the construction site. The construction sites should not be close to streams or ravines.

Permafrost on steep banks is preferred. If the terrain permits, the permafrost inlet is installed north or east, that is, in the direction of the inflow of the coldest winter wind in northern Siberia. The frozen soil can be easily cooled by opening the frozen soil gate during the cold period. Wind erosion shore leads the air flow to the frozen soil gate and thus to a rapid air exchange in the tunnel. In addition, wind ventilation effectively evaporates moisture, which lowers the temperature (evaporation of 1 mL of water requires 2.4 kJ). Wind ventilation can compensate for defects in the design because not all frozen soil layers have enough thrust to freeze the tunnel walls in winter.

The design and calculation of good air thrust based on the temperature difference in the frozen soil area are difficult engineering tasks. Data on the temperature and thermal conductivity of the permafrost and summer and winter temperatures are required. In distal factor analysis, most of the permafrost is constructed based on a schematic drawing on a tissue paper, without complex engineering calculations. The architects are settlers, teachers, and local fishermen.

A complete permafrost network has been constructed in the Yamal–Nenets Autonomous Region and six large permafrost areas are still in operation (Figure 8).

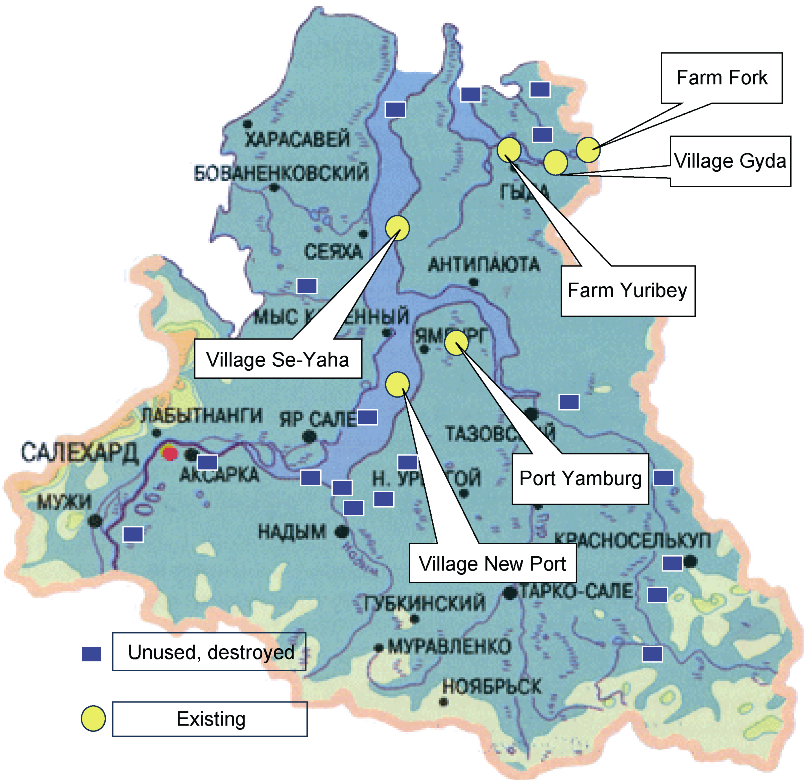

Figure 8 Frozen soil layers in the Yamal area.

Unfortunately, most of the builders of these facilities did not leave their names. The new port was designed by settler Gustav Beckman in 1943. Andrei Ogorodnikov, a regional expert in the village of Xingang, said the following about the construction of frozen soil: “From the 1950s to the 1960s, they have been excavating 24 hours a day, three shifts a day, for 10 years. All permafrost is handmade and does not use machinery” (Figure 9).

Small frozen soil areas were constructed in the upper reaches of the Priobie and Taz rivers, even in soil that was initially not frozen. Construction in this type of permafrost is less laborious. The land can be removed with a shovel instead of a pickaxe. The soil is reinforced with wooden pillars. During the winter, the temperatures in the southern region of the Yamal–Nenets Autonomous Region are lower than –50 °C due to wind and ventilation, and the tunnel walls freeze faster than the surface soil because they are not covered by snow. Artificial frozen soil forms, which can be as wide as 1 m. In the early spring, a wedge is inserted under the reinforced beam because the tunnel geometry may change during the formation of the frozen soil.

Figure 9 Permafrost ice cellar in the Yamal area, 2016.

Mining permafrost requires considerable effort. “Snow porridge” is spread on the wall, and old grease that may contain microorganisms that can negatively affect the storage of fish is removed. The tunnel vault shrinks and deepens due to the ductility of the ice. However, frozen soil is the most economical method of food storage. The combination of frozen soil and modern cold storage is particularly effective. In the first stage, the product is shock-frozen in the cold storage room and then stored in frozen soil. The shock freezing improves the product quality, whereas the frozen soil layer provides long-term storage without energy consumption under optimum humidity conditions.

Refrigerated ships can be used as moving freezers. Fresh fish are immediately “electrocuted” frozen to –20 °C to maintain all nutrients and avoid quality degradation during transport. The labor is largely mechanized. Because the ambient temperature in summer in Yamal is much lower than in regions at higher latitudes, refrigeration equipment can be operated with less fuel (Figure 10).

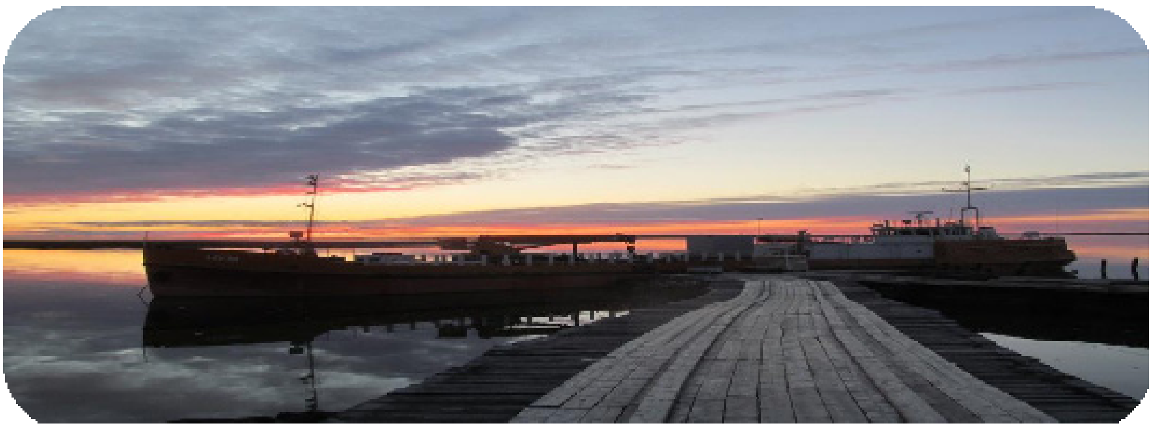

Figure 10 Refrigeration ship “The Num” near Gyda wharf.

3 Significance of traditional fish storage facilities

In the “Rovaniemi Declaration”, which was signed in 2019, it was stated: “The meeting recognized the rights of Arctic indigenous peoples and the unique role of the Permanent Participants within the Arctic Council, as well as the commitment to consult and cooperate in good faith with Arctic indigenous peoples and to support their meaningful engagement in Arctic Council activities. It emphasized the important role of scientific research together with traditional knowledge and local knowledge, in Arctic decision-making and in the work of the Arctic Council" (Arctic Council, 2019).

The traditional knowledge of the indigenous people of the Arctic is receiving increasing attention and is becoming an important tool in the fight against climate change. The indigenous people of the Arctic use the natural environment and products to construct fish storage facilities, which neither leads to environmental pollution nor increases energy consumption. This is of great significance to the protection of the fragile ecology of the Arctic and its sustainable development.

3.1 Typical example of the application of traditional knowledge

Similar to man-made landscapes, humans can also modify low-temperature resources, giving them different characteristics and practical meanings (Melnikov, 2018). The utilization of Arctic low-temperature resources represents a method that is based on the harmonious coexistence of Arctic indigenous people and nature. It is environmentally friendly and causes no pollution. This traditional form of storage facility not only helps develop the economy, but also protects the environment, providing a green and sustainable model for humans to utilize Arctic resources.

Large-scale resource development in the Arctic is imperative due to global warming, but environmental protection and sustainable development must be considered. Mamontova (2017) points out that, "In dealing with climate change, similar research is needed, and indigenous traditional knowledge is displayed as a system of interrelated elements in order to better understand current changes." The traditional knowledge and culture of indigenous people of the Arctic must be combined with modern science and technology to develop Arctic natural resources.

3.2 Environmental protection and reduction of the energy consumption

The Arctic plays an important role in the global environmental system. It is the responsibility of mankind to protect the environment in the Arctic region. However, "black-and-white" thinking is not conducive to the protection of the Arctic environment. However, considering the irreversible global warming trend, the Arctic must be protected, and sustainable development must be achieved (Guo et al., 2020).

Traditional fish storage facilities represent a means for indigenous people to use low-temperature resources. In addition to fish, these storage facilities can be used to store meat and berries. In these facilities, natural ice and snow, frozen soil, and plant resources, such as sphagnum moss, are utilized. Sphagnum moss absorbs heavy metals and water- and fat-soluble toxins, reduces the rate of glucose absorption, promotes food digestion, can be used for long-term storage, and prevents food allergies (Luo et al., 2020).

The traditional fish storage facilities of the aboriginal people in the Arctic are green and environmentally friendly. They consume no energy and thus do not aggravate global warming.

"Cold resources" traditionally played significant roles in sanitation and hygiene. Critical consequences of the "cold deficit" in the winter season include the degradation of permafrost, waterlogging of land, and difficulties in the delivery of vital goods (Suleymanov, 2020). Both global warming and the lack of cold weather are caused by the excessive consumption of energy by humans. Global warming has led to the thawing of Arctic permafrost, flooding of glaciers, and a series of events threatening the survival of Arctic residents. Therefore, reducing the energy consumption and using natural and green facilities are inevitable for the sustainable development in the Arctic.

Fish storage facilities use the low-temperature resources of the Arctic and are of significance to the maintenance of the Arctic ecology.

3.3 Part of Arctic indigenous culture

The five different types of fish storage facilities introduced above reflect the traditional culture of the aborigines of the Arctic. Lightly fermented, marinated fish has a special dietary flavor. Fresh fish preserved in permafrost ice cellars can be used for 30–40 days while maintaining its quality. Sphagnum moss can be used as natural preservative. It can also be filled into a sack as a low-temperature protection layer. The aborigines of the Arctic have used sphagnum moss before modern civilization; it is a part of their culture.

Most areas of the Arctic were inhabited by humans after the last ice age, that is, ~10000 years ago; several areas have an even longer history of human inhabitation (Pan, 2012). Throughout history, the aborigines of the Arctic have used their knowledge to engage in production and business activities, thrive, adapt to the harsh climate, and coexist in harmony with nature. The relationships of people with nature and with each other are social relations; more broadly, sociocultural touristic relationships. Hence, the natural environment (as opposed to nature) is a social phenomenon and concept (Tomilov, 2016).

Fish storage facilities are nature-friendly, consume almost no energy, protect the environment, and conform to the ethnic belief of the indigenous people, that is, that everything in the Arctic is animistic. The folklore and poetry texts of the aboriginal people of the Arctic express a positive view of the cold climate in northern Kola. For example, in the art world of the Sami people, there are cold and warm friends and enemies. The most common images in Sami poetry are snowdrifts and whiteness, which is no accident. Whiteness is an inherent characteristic of cold and severe cold, and is considered to be the symbol of an ancient and comfortable home (Ivanischeva, 2019).

The fish storage facilities of the indigenous people of the Arctic thus conform to the national beliefs and cultural identity regarding ice and snow.

3.4 Exploring ways of sustainable development in the Arctic

Economic development and environmental protection in the Arctic are complex contradictions. However, the large-scale development of the Arctic economy is inevitable. The excavation of various mineral resources in the Arctic will cause environmental pollution. If the burden on the Arctic environment is increased in daily life, it will cause irreversible damage to the fragile Arctic ecology. This would constitute a common loss for all of humankind.

The concept of sustainable development has been supported by many governments. "First and foremost, policy must be guided by sustainability. Sustainability is the basic principle of China's participation in Arctic affairs" (State Council of China, 2018). Russia's support of sustainable development cooperation in the Arctic is primarily based on multi-dimensional, strategic considerations involving development demands, the revival of shipping passages, security arrangements, and legal claims (Zhao, 2018).

With the advancement of Arctic development, the importance of Arctic logistics has become increasingly prominent. The storage of goods is a key aspect of logistics and of maintaining transportation links. Using the natural low-temperature resources of the Arctic to store food and goods is an environmentally friendly approach. It is also a mechanism of sustainable development, as sought by all countries. This storage method is derived from the traditional knowledge of the indigenous people. Indigenous traditional knowledge is thus one of the cornerstones of sustainable development in the Arctic.

4 Conclusions

Recently, the interest in the use of natural cryogenic resources as industrial coolers has increased in several countries because of the rising cost of electricity consumption by modern refrigeration equipment, which is an important factor increasing the cost of food production and in turn reducing the competitiveness of food in the modern market. Ancestral experience can be used as guidance in realizing economic efficiency and meeting the demand of modern cooling systems utilizing natural low-temperature resources.

To achieve this goal, it is necessary to integrate the activities of scientists (frozen soil scientists, biologists, ethnologists, etc.). Therefore, the historical diversity of natural refrigeration and its technical adaptability are studied to develop new energy-efficient and environmentally sound storage and transport technologies that can be effectively utilized under low-temperature conditions.

Based on the development of Arctic waterways and resources, a large number of storage facilities will be required in the Arctic. The traditional fish storage facilities of the aborigines can also be used to store other food such as meat and berries. The traditional fish storage facilities of the aboriginal people in the Arctic utilize natural low-temperature resources and traditional knowledge in line with a green concept and environmental protection. They can be widely used in the Arctic region and promote its sustainable development.

The design of the Arctic Northern fish storage facilities reflects the traditional simple philosophy of ice and snow culture. Different types of fish storage facilities demonstrate the application of traditional simple philosophy to traditional skills, and the comprehensive application of traditional fish storage facilities and modern freezing technologies. It is the use of traditional knowledge, combined with carbon neutralization concepts that will inspire new technological innovation to produce a bright future of sustainable development.

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