Traditional conservation on Chinese Metal Coins (Kepeng) from *sangkulu-kulu* underwater archaeological sites, Selayar Regency

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Abstract. This study aims to carry out conservation using a traditional approach to the artifacts of Chinese metal coins (kepeng) that are raised from the Sangkulu-kulu Selayar underwater site. The natural ingredients used are a solution of *wuluh* starfruit (*Averrhoa Bilimbi*), *maja* fruit solution (*Aegle Marmelos (L) Correa*), lime juice (*Citrus Aurantifolia*), tamarind juice (*Tamarindus Indica*) and coconut water (*Cocoa nutifera*). The methods used include identification of weathering. The second stage is of XRF analysis. The third stage is immersion with a conservative ingredients solution. The results showed that of the five solutions used in the cleaning of 3 types of weathering in the coin sample, the lime solution was faster in removing three types of weathering (chemistry, physical and biotic), especially for the types of chemical and biotic weathering. Acidic solutions are used to remove active patina; a tamarind solution is the most effective solution in eliminating physical weathering by a process that lasts slowly or little by little.

1. Introduction

One of the underwater Archeology sites in South Sulawesi that contains Chinese coin artifacts is located in Selayar Island, South Sulawesi Province. This place is named the Sangkulu-Kulu Underwater Archaeological Site in the Bonto Sikuyu. These artifacts were once illegally appointed by irresponsible individuals in 2009. However, they were finally secured by the government of the Kepulau Selayar Regency and stored in the Tanadoang Museum [1].

In 2010, the museum collection coins were conserved by the South Sulawesi Cultural Conservation Center (BPCB) using synthetic chemicals, namely citric acid. However, the results are not maximal; continuing damage still occurs to the coin. Cleansing using chemicals can worsen the condition of the artifact if it is not done properly. The worst condition is the loss of data attached to artifacts. Therefore, cleaning with the traditional method is the right step to minimize the continued form of damage to the artifact.

This study tried to clean up Chinese coin artifacts from underwater using natural materials (traditional conservation methods) because the method had never been done on metal coin artifacts from underwater. The results of the study are expected to be a solution to the handling of weathering that occurs in metal artifacts from the underwater Archeology Site without removing the archaeological data attached to the artifacts of the metal coins.
2. Material and Method

2.1. Material

Conservative ingredients used are lime (Citrus Anurantifolia), wuluh starfruit (Averhoa blimbi L), Tamarind (Tamarindus indica L), coconut water (Cocos Nutifera) and maja fruit (Aegle Marmelos). The five ingredients all contain compounds in the form of acids, but the acidity levels vary. The use of these conservative materials is based on the results of reports about being used by some conservators in handling BCB made from metal [2][3][4]. In addition, these five conservative ingredients are also very easily found in the location of the existence of Chinese coin artifacts.

2.2. Weathering Identification

The first stage is the identification of weathering that occurs on metal coins (chemistry, physical, and biotics). Then it continued with the description and shooting of Chinese coin artifacts. It was done based on the document, the object of research. After the description and shooting, then the artifacts are analyzed for the elements to be carried out in a chemical laboratory. The laboratory analysis was carried out to find out the content of the elements in Chinese coin artifacts.

2.3. XRF Analysis

X-RF analysis (X-Ray Fluorescence) was carried out in the Chemistry laboratory of the Faculty of Mathematics and Natural Sciences, University of Hasanuddin, Makassar. Based on the results of the XRF analysis of two samples of coins tested, these Chinese coin artifacts contained several elements. Among them are copper (Cu), lead (Pb), tin (Sn), iron (Fe), silicon (Si), silver (Ag), nickel (Ni), and many other elements. Each element has a different size value, as well as the standard error. The Chinese one coin sample has 14 element elements from the 14 elements. The highest element value is copper (Cu). Whereas in sample 2, it has 13 elements and elements of copper, which have the highest elemental value. For more details, can be seen in the following Table 1.

| Table 1. China coin 1 sample content and China coin 2 sample Content. |
|---------------------------------------------------------------|
| **China coin 1 sample content** | **China coin 2 sample Content** |
| El | m/m (%) | Std.Err | El | m/m (%) | Std.Err |
| Cu | 42.32 | 0.25 | Cu | 59.72 | 0.25 |
| Pb | 33.60 | 0.23 | Sn | 18.31 | 0.19 |
| Sn | 18.03 | 0.19 | Pb | 15.35 | 0.18 |
| Fe | 2.95 | 0.25 | Si | 2.37 | 0.32 |
| Si | 1.58 | 0.29 | Fe | 2.09 | 0.25 |
| Ni | 0.379 | 0.082 | Px | 0.725 | 0.098 |
| Sb | 0.337 | 0.021 | Ni | 0.600 | 0.054 |
| Nb | 0.205 | 0.023 | Ag | 0.341 | 0.027 |
| Mo | 0.176 | 0.019 | Nb | 0.170 | 0.019 |
| Ag | 0.125 | 0.031 | Mo | 0.127 | 0.015 |
| In | 0.120 | 0.057 | Sb | 0.093 | 0.021 |
| Ru | 0.078 | 0.019 | Ru | 0.054 | 0.015 |
| Sr | 0.060 | 0.020 | Rh | 0.041 | 0.015 |

**Notes**

El: element, m/m%: percentage, Std.Err: standard of error, Cu: cuprum, Sn: stannary, Pb: lead, Si: silicon, Fe: Ferro, In: indium, Ag: argent, Nb: niobium, Mo: molybdenum, Sb: antimony, Px: Fosport, Ru: Ruthenium, Rh: rhodium
2.4. Conservation procedure
Before carrying out the conservation, tools, and materials are prepared. The equipment needed is in the form of writing instruments, toothbrushes, iron/tongs, digital scales, pH meters, electric ovens, tubers, calipers, four pieces of cup, and chemical glasses/becker glass 100cc and 50cc 5 pieces. The conservation procedures in this research include the following: (1) Measuring artifact dimensions using digital scales and clippers. (2) Artifacts are divided into five groups consisting of 3 types of weathering then proceed with labeling in each artifact. (3) Artifacts are desalinated using distilled water to neutralize and break down the salt in the artifact. (4) Immersion implementation, with four immersion models, namely first immersion with 2 hours, second immersion with 4 hours, third immersion with 1x24 hours, and fourth immersion with 2x24 hours. (5) Cleaning using three models, namely nonmechanical cleaning, mechanical cleaning using a toothbrush (mechanical 1), mechanical cleaning using scalpel, and needles (mechanical 2). (6) After cleaning, coin artifacts are dried under direct sunlight for ± 2-3 hours or by using the oven for 5 minutes with hot temperatures reaching 660c. (7) Re-measuring the dimensions of coin artifacts, which are useful for knowing the size before and after the conservation is carried out.

3. Results and Discussion
3.1. Immersion with lime fluid
Lime is a fruit that has acidity reaching number 2 on a pH scale of acidity and basicity. Lime can be categorized as an acid that has a high acidity level. So it is often used in various needs, one of which is used as a cleaning agent. The level of acidity of the lime can lift some types of dirt on the object. It is like the dirt or weathering that is owned by Chinese coin artifacts in the form of weathering, physical, and biotic.

Based on the results of the soaking that has been done, the lime is able to clean three types of weathering on Chinese coin artifacts quickly. Hygiene that occurs in Chinese coin artifacts starts at the second immersion, which is soaking for 4 hours. The clean Chinese coin artifact is an A2 sample with weathering conditions in the form of physical weathering, which can be characterized by the presence of white salt deposits. Cleanliness that occurs does not use mechanical materials such as toothbrushes at all, but only by washing with water flowing from the tap. The frequency of cleaning the A2 sample in this second immersion is 90%, and the third soaking frequency has reached 100%. The cleaning model performed on the third immersion is the cleaning model using a toothbrush or mechanical model I.

Two other samples, namely samples A1 and A3, have experienced cleanliness at the third and fourth immersion. In the third immersion, the two samples experienced very significant cleanliness. A1 samples have a cleanliness level reaching 95% at the third immersion. After cleaning using a toothbrush, the salt deposits attached to the A1 sample have been reduced and almost even run out on the surface of the sample. But at the fourth immersion, the cleanliness level has increased to 100% with the cleaning method still the same, namely mechanical I. Hygiene that occurs in this fourth immersion, lime juice only takes 2 hours to clean the remaining salt deposits in the sample. At the same time, the A3 sample experienced cleanliness at the third immersion. The cleanliness level experienced by this A3 sample reached 100%. This cleanliness occurs because it is assisted by a mechanical cleansing model that is by using a toothbrush. Initial coral deposits have covered a number of characters, or the writing of a coin appears to not leave a single trace of coral deposits. Thanks to the cleanliness, the writing of coin letters that initially cannot be identified directly can be identified.
Table 2. The results of soaking with lime juice.

| Sample | Before Immersion | After Immersion | Duration |
|--------|------------------|-----------------|----------|
| A1     | ![Image]         | ![Image]        | 30 hours |
| A2     | ![Image]         | ![Image]        | 32 hours |
| A3     | ![Image]         | ![Image]        | 30 hours |

3.2. Immersion with coconut water

Coconut water is the second material used in this experimental study. The acidity level of coconut water is reaching number 4 on the pH scale of acidity and basicity. The acidity level of coconut water is not as high as the acidity of lime juice. But the acid level possessed by coconut water is also capable of clearing three types of weathering experienced by Chinese coin artifacts.

From the results of four immersion observations, coconut water gave the first change to the sample used in the third soaking, 24 hours of immersion. All samples in this solution of coconut water undergo changes, but the level of change varies. They are starting from sample B1, which experienced chemical weathering, which can be characterized by the presence of white deposits on the surface of the sample. These salt deposits are different from coral deposits, although the color is the same, the difference can be seen in their shape and texture. The changes experienced by sample B1 are more dominant changes in the color of the sediment, while the level of cleanliness is very small, which only reaches 5%. The cleaning model used in cleaning B1 samples is by using a toothbrush. In the fourth immersion, the level of cleanliness has slightly increased, but only on a small scale, reaching only 15%.

Other samples, namely B2 and B3 samples, also experienced changes in the third immersion with a cleaning process using a mechanical model I. Sample B2 is a sample that undergoes physical
weathering in the form of a light green layer deposited concentrated in the Chinese coin characters. The patina, when cleaning using a toothbrush, looks lifted and detached from the surface of the sample. So the sample looks very clean from the patina that settles, and the color of the sample becomes light brown that resembles the corrosion marks on the iron metal. This light brown color is not the original color of copper metal, but the color is most likely corrosion originating from iron metal elements and considering that this coin artifact also contains an element of iron in its manufacture.

B3 sample is a sample that has experienced biotic weathering characterized by the deposition of white coral on the surface of the sample. But the size of the coral deposits is not as large as the coral deposits in the A3 sample. When cleaning using a toothbrush, the coral deposits are slightly reduced on the surface of the sample. This can be seen with the size of the sediment getting smaller and looks thinner than before. The frequency of cleanliness experienced by the sample in this third immersion is reaching 65%. In the fourth immersion, the level of cleanliness is increasing, which can be seen with the condition of coral deposits that are smaller in size and even look almost exhausted on the surface of the sample. The cleanliness level experienced by the sample in this fourth immersion was 97%. In the fourth immersion, the cleaning model used is cleaning using a knife or scalpel.

Table 3. Results of soaking with coconut water.

| Sample | Before Immersion | After Immersion | Duration |
|--------|------------------|----------------|----------|
| B1     | ![Image](image1)  | ![Image](image2) | 78 hours |
| B2     | ![Image](image3)  | ![Image](image4) | 30 hours |
| B3     | ![Image](image5)  | ![Image](image6) | 78 hours |
3.3. Soaking with Javanese solution
Tamarind solution is one of the ingredients consisting of acids mixed with distilled water with a comparison scale of 1:1 where the two ingredients of the membrane are 30 grams of tamarind and 30 ml of distilled water. The tamarind acid solution has an acidity level reaching two on the pH scale of acidity and basicity. The acidity of the acidic solution of Java is the same as the acidity of the lime. However, changes or cleanliness in the sample, which is treated by tamarind, is much different from the lime.

Based on the results of immersion using the Javanese acid solution, all of the samples dissolved have undergone a change. The first sample to get a change is the sample C1 and C2. Both of these samples experienced changes in the second immersion, but the frequency of changes obtained was very small. The sample C1, which experienced chemical weathering initially experienced deposition of salt, whose condition was not too dominant, covering the surface of the sample. However, when cleaning, the sample undergoes a significant change, where the salt deposition conditions predominantly cover the surface of the sample. The salt deposits also look a little thinner than before. The cleaning frequency experienced by this C1 sample is 15%.

In subsequent immersion, the cleanliness level of C1 samples increased to 35%. At the last immersion, the fourth immersion for 48 hours, the level of cleanliness is getting bigger. The frequency of cleanliness that occurs reaches 95%. So, the deposits appear to settle are very little on the surface of the sample. However, in this fourth immersion, sample C1 undergoes new weathering, which is physical weathering characterized by the presence of a green patina layer. This patina layer is indeed covered by salt deposits.

In addition, sample C2, which both experienced changes in the second immersion level, were greater than the sample C1. The C2 samples that experienced physical weathering reached a level of 20% cleanliness. The patina condition that settles on the surface of the sample looks slightly thinner than before. However, in the third immersion, the frequency of cleaning of C2 samples increased more, where the cleanliness level occurred to be 70%. Patina, which was previously whitish green in the C2 sample, appeared to change color to be somewhat grayish. The green patina color has been obscured by the new color so that the color of the patina is not clearly visible on the surface of the sample. In the immersion of the four samples, C2 experienced cleanliness reaching 100%; this was indicated by the condition of the sample, which was no longer endured by the patina at all.

While the new C3 sample changes during the fourth immersion. C3 samples experience biotic weathering, which is characterized by white coral deposition. Changes that occur in this fourth immersion, the frequency of cleaning of C3 samples is not too large. Namely, 55% as much as two coral deposits attached to the surface of the sample has been released. The dominant coral deposits are located in the uppermost part of the writing script. The other part is on the right side of the sample, the coral deposits still look intact, not having the slightest release. In fact, this C1 sample has been cleaned using a needle as a tool to lift the coral deposits that are still attached.

### Table 4. The results of soaking with acidic Java solution.

| Sample | Before Immersion | After Immersion | Duration |
|--------|------------------|-----------------|----------|
| C1     | ![Image](image1.png) | ![Image](image2.png) | 78 hours |
3.4. Soaking with maja fruit juice solution

*Maja* Fruit is the fourth material used in this experimental research. The acidity of this material reaches number 5 on the pH scale of acidity and basicity. The acidity level of the *maja* is the lowest among the ingredients I use. But the acid level possessed by the *maja* is also capable of clearing three types of weathering experienced by Chinese coin artifacts.

From the results of observations made on *maja* juice, the sample undergoes a change which is at the third immersion. Where changes occur, apply to all samples that are on *maja* fruit juice. It is starting from sample D1, which is the deposition of salt. When cleaning using a toothbrush, sample D1 looks slightly cleaner than salt deposits. The precipitated salt has been lifted and detached from the surface of the sample, but the frequency of departure is only 55%. In the fourth immersion, sample D1 increasingly shows the level of cleanliness. The frequency of cleanliness is 95%, where the salt deposits attached to the surface of the sample are very small.

As with the sample D1, sample D2 is also one of the samples that experienced a change in the third immersion. The initial condition of the D2 sample before immersion both first immersion to the end was seen deposited by the active patina. This can be seen in the sample reached by bright green sediment found on the surface of the sample. After cleaning using a toothbrush, the sample experienced a very significant change. The active patina that settles on the surface of the sample has been removed and removed completely so that the sample looks very clean from patina deposits that are at risk as a destroyer. So, the cleanliness level achieved by this D2 sample is 100%.

While the D3 samples that experienced biotic weathering, the cleanliness frequency that occurred in the third period were not as big as what happened in the previous two samples, the D3 sample only experienced small-scale erosion. The coral deposits that brush on the surface of the sample are only slightly released, which can be characterized by the smaller size of the sediment. But in the fourth immersion, the frequency of cleanliness is very severe. The rest of the coral deposits are still attached to the surface of the sample is clean without the slightest deposit of deposits, so that the cleanliness reaches 100%.
Table 5. Soaking results with *maja* fruit juice.

| Sample | Before Immersion | After Immersion | Duration |
|--------|------------------|-----------------|----------|
| D1     | ![Image](image1) | ![Image](image2) | 78 hours |
| D2     | ![Image](image3) | ![Image](image4) | 30 hours |
| D3     | ![Image](image5) | ![Image](image6) | 78 hours |

3.5. Immersion with Wuluh Starfruit Juice Solution

Wuluh starfruit is the last material used in this experimental study. The acidity of this material reaches number 3 on a pH scale of acidity and basicity. This level of acidity is one level below the acidity level of the lime and tamarind. The acid contained by the *wuluh* starfruit is also capable of cleaning three types of weathering experienced by Chinese coin artifacts.

Based on the results of the observations, when the immersion process took place, all the samples in the solution of Wuluh starfruit had undergone a change, but the changes that occurred at different levels were different. Each sample shows its respective changes, which consist of very small changes to a considerable change. It starts in sample E1, which begins to change even if only the color of the sediment. Where previously, the sediment has a white-brown color, but after cleaning with it, the salt deposits turn yellow or yellowish. The salt deposits which bind the E1 sample cannot yet be lifted and detached from the sample so that there is absolutely no significant change in the salt deposits except the color. But a significant change occurred at the fourth immersion. Samples that are still covered by salt deposits in the third immersion become more reduced after cleaning in the fourth soaking. This can be seen in the sample whose condition is no longer visible covered by yellow salt deposits. Salt deposits are only visible on the sidelines of writing coin letters. The level of change that occurs in this E1 sample is reaching 60%
In addition to the E1 sample, E2 samples also experienced changes in cleanliness. The sample that experienced physical weathering had initially undergone changes in the third immersion; the rate of change only reached 65%. But at the time of the fourth immersion, the level of cleanliness increased, which reached 100%. In this case, the E2 sample that has the deposition of the patina has been clean in a whole manner from the patina. In comparison, the E3 sample changes almost the same as the changes experienced by sample E1. It’s just that the E3 sample rate of change or cleanliness is greater than the sample E1, wherein the third immersion, the E3 sample had a cleanliness level of 55%. Then at the time after the fourth immersion, the level of cleanliness experienced by this E3 sample increased to 95%. So that the sample looks clean from coral deposits, and also the Chinese characters in the sample are also seen more clearly. The cleaning technique performed on the fourth immersion is a mechanical cleaning model using a needle knife.

| Sample | Before Immersion | After Immersion | Duration |
|--------|------------------|-----------------|----------|
| E1     | ![Image](image1)  | ![Image](image2) | 78 hours |
| E2     | ![Image](image3)  | ![Image](image4) | 30 hours |
| E3     | ![Image](image5)  | ![Image](image6) | 78 hours |

Based on observations and results obtained from the first immersion to the end, it can be seen that which solution is capable of lifting and releasing 3 (three) weathering effectively. The use of this effective word refers to three perspectives, namely, the rate of weathering and release (chemistry, physical and biotic), the rate of weathering and weathering, and the color changes resulting from immersion processes. The graph of changes experienced by all samples from the immersion results are as follows:
Based on the results of immersion carried out for four times immersion, which can be concluded is, of the five juice used in cleaning three types of weathering in the coin sample, lime juice is faster in removing three types of weathering (chemistry, physical and biotic), especially for types chemical and biotic weathering. Lime juice only takes 30 to 32 hours to clean the weathering experienced by coin artifacts.

The other four presses are capable of cleaning weathering within 78 hours, which is for four times immersion. Samples of B1, which experienced chemical weathering on coconut water juice, have not been able to clean perfectly for four times soaking. But the other two samples were able to clean perfectly for four immersion times. In tamarind juice, all samples were not able to clean as a whole; the cleanliness only reached 55 to 95%. This happens because the cleaning process that occurs in tamarind juice is gradual, or little by little erosion occurs.

The juice from maja (starfruit) experiences cleanliness, which is almost the same as the cleanliness of coconut juice. Where the juice of the maja is able to clean weathering reaches 100% in two samples, namely physical and biotic samples. Samples that experience chemical weathering are only 95%. In the juice of starfruit, hygiene occurs in a variety, where the samples with chemical weathering only reach 60%. Samples that experienced physical weathering experienced cleanliness reached 100%, and samples with biotic weathering reached 95% cleanliness.

4. Conclusion
Based on the five solutions used in cleaning three types of weathering in the coin sample, the lime solution is faster in removing three types of weathering (chemistry, physical and biotic), especially for the types of chemical and biotic weathering. Acidic solutions are used to remove active patina. Acidic solutions are the most effective solutions in eliminating physical weathering with processes that take place slowly or little by little. So, it can be concluded that conservative ingredients that are good for dealing with damage both physically, chemically, and biotically can be used as lime juice. For special handling of physical weathering, you should use tamarind liquid.

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References
[1] Mulyadi Y 2014 Potensi Situs Cagar Budaya Bawah Air Sangkulu-Kulu Di Perairan Bontosikuyu, Kabupaten Selayar Sulawesi Selatan J. Varuna 8
[2] Titasari and Palupi C 2014 Penggunaan Jeruk Nipis sebagai salah Satu upaya Konservasi Secara Tradisonal pada Prasasti Sukawana J. Konserv. Cagar Budaya Borobudur 8 76–86
[3] Fatmawati I 2014 Efektivitas Buah Lerak (sapindus Rarak De Candole) sebagai Bahan Pembersih Logam Perak, Perunggu dan Besi J. Konserv. BCB Borobudur V 8 24–31
[4] Mustafa 2015 Bahan Alami sebagai Alternatif perawatan Cagar Budaya (Makassar: Balai Pelestarian Cagar Budaya Makassar)