MATERIALS AND METHODOLOGY

3. MATERIALS AND METHODOLOGY

3.1. COLLECTION AND ALKALIZING FRESH HUMAN URINE

Fresh human urine was collected anonymously from both male and female donors (aged 18-65) at the Department of Energy and Technology, SLU. 500 mL sterile polypropylene urine donation containers were put in every washroom of the department. The donations were strictly voluntary and were collected twice every day, at intervals of 4 hours and stabilized to prevent enzymatic hydrolysis of urea to ammonia. The donations were pooled together and dosed with 10 g $Ca(OH)_2$ L^{-1} (Experiments I, II and IV) (Randall et al., 2016) or with NaOH was used to adjust the pH to 11 or 14 (Experiment III) (Randall et al., 2016). Urine and chemicals were mixed at 300 rpm for 30 min using a propeller (R 1345, 4-bladed, Ø100 mm, 540 mm) connected to a digital overhead stirrer (OHS 60, Velp Scientifica, Italy). The treated urine was then allowed to stand undisturbed overnight to settle out precipitates.

3.2. DEHYDRATING THE URINE

The urine was dehydrated to Concentration Factor (CF) 2 (Experiment I), Concentration Factor (CF) 10 (Experiment III) and Concentration Factor (CF) 5 or 12 hours (Experiment IV). For CF 2, the urine was dehydrated to 50% of its original mass using a CO_2-free dryer (Daycare DC3600EWL, Electrolux, Sweden). For the CF 10, the urine was dehydrated to a tenth of the original mass using 2 heater fans (40-137, Biltema, Sweden) that provided airflow directly onto the surface of the drying urine. To dehydrate to CF 5, a fifth of the original mass, or for 12 hours, an aquarium pump (200W) was used to induce turbulence in the circular urine dehydrating setup.

3.3. PREPARATION OF THE POLYMER FILMS AND POUCHES

Experiment I analysed the degradation of four polymers in unconcentrated and concentrated urine. Laboratory-grade polypropylene (PP) pellets (Merck Chemicals GmbH, Darmstadt, Germany), polycaprolactone (PCL) flakes (Merck Chemicals GmbH, Darmstadt, Germany), polyvinyl alcohol (PVOH) powder (Fully Hydrolysed, Merck Chemicals GmbH, Darmstadt, Germany) and polylactic acid (PLA) pellets (Good Fellow, England) were used to fabricate 2 mm thick polymer films. PP, PCL and PLA films were

fabricated using the heat pressing technique. It involves polymers heated to their respective melting temperatures on a non-stick surface and then applying pressure from the top to adjust the thickness to 2 mm. PVOH films were fabricated by solution polymerization technique using distilled water as solvent. PVOH powder was mixed with distilled water while heating it at the melting temperature until a uniform viscosity was reached. The polymer was then spread on a non-stick surface till a uniform thickness of 2 mm was achieved. The fabricated polymer films were cut into circles of 2 cm diameter and weighed before use.

Experiment II used bi-axially oriented Poly L-Lactic Acid biopolymer films (Goodfellow Cambridge, UK) to evaluate the effect of film thickness, pH and temperature on the degradation. The film had an initial thickness of 0.05 mm. To fabricate films of different thicknesses (0.1 mm and 0.25 mm) PLLA was heat-pressed in an oven at 160 °C for 1 h and fabricated into square films (30 mm × 30 mm). To fabricate 0.1 mm thick films, two 0.05 mm thick films were put together, facing each other and heat pressed. For 0.25 mm thick films, five, 0.05 mm films were put together and heat pressed.

Experiment III employed the same PLLA films utilized in Experiment II. These films were cut into three different sizes, 4×4 cm, 5×5 cm and 6×6 cm, and then sealed together using a heat sealer to create the pouches. The process involved packing 0.2 g of KOH (Merck, Darmstadt, Germany) between 0.5 g of microcrystalline cellulose powder (Thermo Fisher Scientific, USA) and pelletizing the mixture. KOH was surrounded by cellulose to limit its hygroscopic activity. The experiment was conducted at 20 °C, with two different concentration factors and pH of urine, for thirty-two days. The KOH/cellulose pellet was enclosed in a 4×4 cm PLLA pouch for the one-layer dosing system. The 4×4 cm pouch containing the pellet was placed inside a 5×5 cm PLLA pouch and sealed to fabricate the two-layer dosing system. Finally, the three-layer dosing system was created by placing the two-layer system inside a 6×6 cm PLLA pouch and sealing it.

3.4. FILTRATION SETUP

The filtration process for Experiments I-III involved the use of a filter paper with a pore size of 3-5 µm (Grade 390, Ahlstrom Munksjö, Sweden) to separate the urine from degrading polymer and other residues. The urine was filtered through this filter paper and any particles remaining in the glass vessel were collected by flushing with 50 mL of Mili-

Q water and filtered through the same filter paper used for the main sample. The filtered urine was stored in falcon tubes for further analysis, while the solid residue collected on the filter paper was dried at 40 °C for 24 h and then stored for further analysis.

3.5. THE CIRCULAR URINE DEHYDRATING SETUP AND THE SUPERABSORBENT POLYMERS (SAPS)

The circular setup (Fig. 2) for experiment IV was designed using three glass airtight containers (IKEA, Sweden). The urine dehydration chamber (chamber 1) which contained the urine for dehydration was constructed in a cylindrical container (Ø12.5 cm, vol = 1.75 L), while the two moisture absorption chambers (chamber 2 and chamber 3) which absorbed moisture from humid air via SAPs were built in rectangular boxes (vol= 1L). Petroleum jelly was applied to container rubber seals to further restrict airflow. Two holes were drilled in the lids of each chamber to attach the air inlet and outlet airtight connectors (Ø12 mm) sealed with O rings. Sterile silicone hoses (Ø12 mm) were used to connect all the chambers. An aquarium air pump (200 W) was employed between chambers 3 and 1 to induce turbulence in the drying unit and recycle the air. In the linear setup, chamber 3 was not connected to the pump. Sodium Polyacrylate (NaPAc) and Potassium Polyacrylate (KPAc) (Alquera Ciencia SL, Spain) were evenly distributed in both moisture absorption units individually or in a 1:1 ratio mixture.

3.6. EXPERIMENTAL SETUPS

3.6.1. EXPERIMENT I

The degradation of films prepared from the four different polymers was analysed in the two types of alkalised fresh urine (CF1 urine and CF2 urine) at 20 °C over 16 days. At the start of the experiment, 80 mL of urine and a polymer film were added to glass Petri dishes (diameter 100 mm, height 15 mm; VWR, USA). The Petri dishes were then placed in closed opaque boxes and kept at 20 °C. On days 2, 4, 8 and 16 of storage in these conditions, the Petri dishes were withdrawn and urine and the polymer films were sampled destructively. The urine samples were collected after filtration using filter paper with pore size 3-5 µm (Grade 390, Ahlstrom Munksjö, Sweden). Solid residues of the polymer films that remained on the Petri dishes were collected by flushing with 50 mL

Milli-Q water and filtering through the same filter paper, which was dried at 40 °C for 24 h and finally weighed.

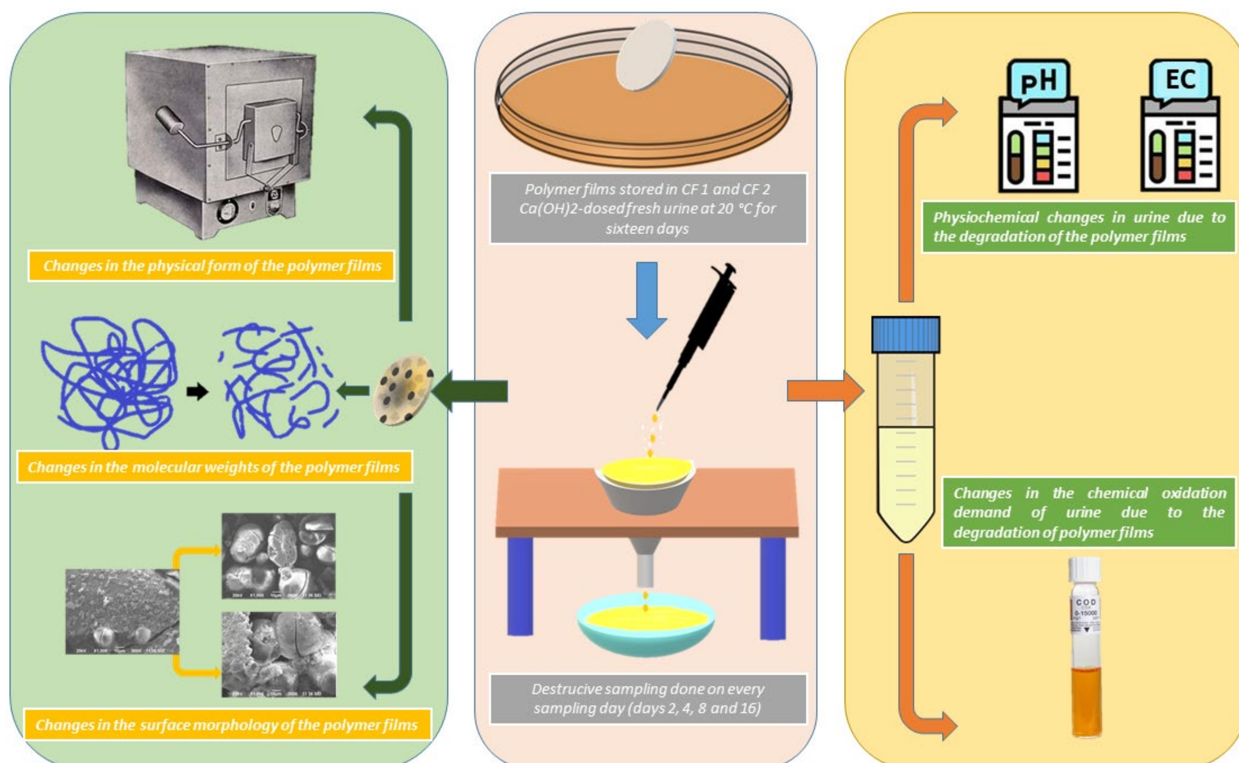


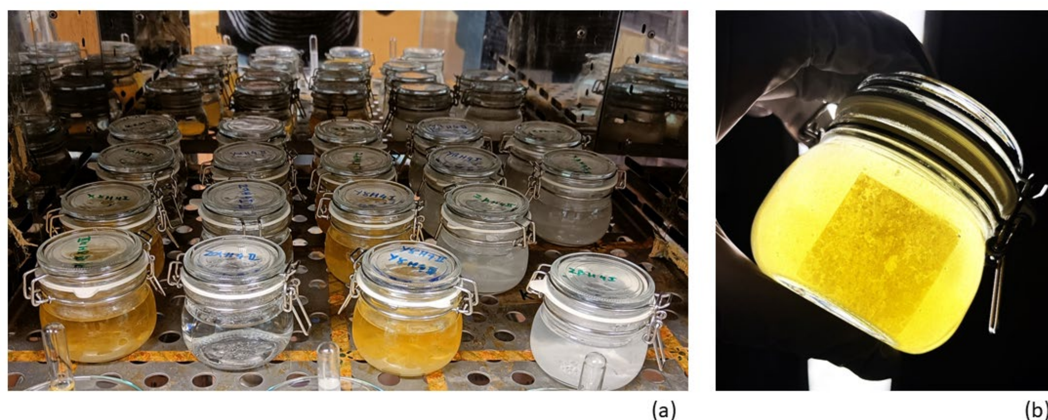
Figure 8: *An illustrative outline of Experiment I.*

3.6.2. EXPERIMENT II

The experiment evaluated the degradation of PLLA films of different thicknesses in $Ca(OH)_2$ dosed fresh urine at two temperatures (20 °C and 45 °C) over 8 days. First, 100 mL of $Ca(OH)_2$ dosed urine and a PLLA film sample were added to air-tight clear glass vessels. The vessels were then placed in closed opaque boxes at 20 °C or in an incubator (Heratherm IGS400, Thermo Scientific, USA) set to 45 °C. After two, four and eight days of storage in these conditions, the urine and PLLA films were sampled destructively. As a control, the same procedure was performed using Milli-Q water instead of human urine.

The urine collected was subjected to filtration, using filter paper with a pore size of 3-5 µm (Grade 390, Ahlstrom Munksjö, Sweden), and stored at room temperature for further analysis. Any particles that remained in the glass vessel were collected by flushing with 50 mL of Milli-Q water and filtered through the same filter paper which was used for the

main sample. The filtered urine and the solid residue collected on the filter paper were dried at 40 °C for 24 h.



(a) (b)

Figure 9: *(a) Experiment set up of Experiment II at 45 °C. (b) 0.25mm thick PLLA film stored in urine at 20 °C at day 2.*

3.6.3. EXPERIMENT III

This experiment was designed to evaluate the time-dependent release of KOH into alkaline urine via the degradation of PLLA pouches. The pouches were made into three different structures. The experiment was done at 20 °C and two different concentration factors and pH of urine for thirty-two days. The KOH/cellulose pellet was sealed inside a 4×4 cm PLLA pouch to fabricate the one-layer dosing system. To fabricate the two-layer dosing system, the 4×4 cm pouch with the pellet was put inside a 5×5 cm PLLA pouch and sealed. Finally, to fabricate the three-layer dosing system, the two-layer system was put inside a 6×6 cm PLLA pouch and sealed. 100 mL urine and a PLLA dosing system were added to air-tight clear glass vessels. The vessels were then placed in closed opaque boxes at 20 °C. After two, four, eight, sixteen, twenty-four and thirty-two days, the urine and PLLA dosing systems were sampled destructively. As a control, the same procedure was performed using PLLA dosing systems without pellets.

The urine was filtered using a filter paper with a pore size of pore size of 3-5 μm (Grade 390, Ahlstrom Munksjö, Sweden) and stored at room temperature for further analysis. Any particles that remained in the glass container were collected by flushing with 50 mL

of Milli-Q water and filtered through the same filter paper which was used for the main sample. The solid residues collected on the filter paper were dried at 40 °C for 24 h.

Figure 10: *(a) A 1-layer pouch. (b) A 1-layer pouch, 2-layer pouch and 3-layer pouch (left to right).*

3.6.4. EXPERIMENT IV

Two sets of experiments were conducted in this investigation. The objective of the first experiment was to evaluate the difference in pH and drying rate when urine is concentrated by convective dehydration, with and without recirculation of air. Urine was dried to a CF 1.25, 2, 2.5 and 5 in chamber 1 in linear and circular setups while the moisture was absorbed by SAPs in chamber 2 and chamber 3. When a specific CF was reached, the pH of the urine was measured in chamber 1 and the drying rate was measured based on the time taken to dehydrate the urine to the specific pH. The objective of the second experiment was to measure the moisture absorption rate and extraction of water from the superabsorbent polymers. The circular configuration of the dehydration setup was used for this experiment. 50 g urine was put in chamber 1 and dehydrated till a constant weight was achieved which marked the end of a drying cycle while moisture was absorbed in chambers 2 and 3. 46 g (± 2%) urine was dehydrated in each drying cycle. 100 g SAP was used in every drying cycle which was distributed evenly between both absorption chambers (50 g in each chamber).

The absorbed moisture by the SAPs was extracted as water using a rotary evaporator (Buchi R150, Germany). The extracted water was divided equally into parts. One part of the water was mixed with activated carbon (0.1 g L-1) (Merck KGaA, Germany) for 30

minutes and then passed through a 0.45 µm syringe filter (Filtropur S, Sarstedt, Germany) before being stored at 4 °C for further analysis. Each test was repeated in duplicates or triplicates to ensure precise results.

Table 5*: Summary of the objectives, materials, setup and key parameters of the experiments.*

Experiment	Objective	Materials/Setup	Key Parameters
Experiment I	To analyze polymer degradation in urine	**Materials**: Polymers: Polypropylene (PP), Polycaprolactone (PCL), Polylactic acid (PLA), Polyvinyl alcohol (PVOH). **Setup**: Polymer films (2 mm thick) fabricated via heat pressing (PP, PCL, PLA) or solution polymerization (PVOH); urine alkalized with $Ca(OH)_2$ at 10 g/L. Petri dishes with polymer films submerged in alkalized urine and incubated at room temperature (20°C).	Temperature: 20°C; Time: 16 days; Urine concentration factors (CF): 1 and 2. Sampling intervals: 2, 4, 8, and 16 days. Urine pH: ≥10. Physical, chemical, and morphological changes monitored.
Experiment II	To evaluate the effects of thickness, pH, and temperature on PLLA degradation	**Materials**: Poly-L-lactic acid (PLLA) films of thicknesses 0.05, 0.1, and 0.25 mm. **Setup**: Films fabricated via heat pressing and placed in alkalized urine dosed with 10 g/L $Ca(OH)_2$. Experiments conducted in clear air-tight vessels at two temperatures (20°C and 45°C). Control samples prepared using Milli-Q water instead of urine.	Film thickness: 0.05, 0.1, and 0.25 mm; Temperatures: 20°C, 45°C; Time: 8 days. Sampling intervals: 2, 4, and 8 days. Crystallinity, molecular weight, and surface morphology analyzed.
Experiment III	To assess controlled chemical release via PLLA pouches	**Materials**: PLLA films (4×4 cm, 5×5 cm, 6×6 cm) fabricated into single-layer, two-layer, and three-layer pouches. **Setup**: Pouches filled with 0.2 g potassium hydroxide (KOH) and 0.5 g microcrystalline cellulose powder to control release rates. Sealed pouches	Pouch layers: 1, 2, and 3; Temperatures: 20°C; Urine CF levels: 2 and 10; Time: 32 days. Sampling intervals: 2, 4, 8, 16, 24, and 32 days. Chemical release rate and urine pH measured.

		immersed in alkalized urine with CF 2 and CF 10. Incubated in air-tight containers for chemical release testing over time.	
Experiment IV	To compare linear vs circular urine dehydration systems	**Materials**: Circular and linear setups incorporating superabsorbent polymers (SAPs): sodium polyacrylate (NaPAc), potassium polyacrylate (KPAc), and a 1:1 mix. **Setup**: Circular system with three interconnected chambers (urine dehydration chamber and two moisture absorption chambers). Moisture absorbed by SAPs, and air recycled using an aquarium air pump. Linear system excluded air recirculation.	SAP capacity: 100 g (50 g/chamber); Urine weight per drying cycle: 46 g; Concentration factor (CF): 1.25, 2, 2.5, and 5. Time-dependent drying and moisture absorption rates analyzed.

3.7. CHARACTERISATION

3.7.1. pH AND ELECTRICAL CONDUCTIVITY

Urine pH (Experiments I-IV) was measured using a glass electrode (Metrohm iUnitrode with Pt1000, 6.0278.300, Switzerland) and electrical conductivity (EC) (Experiment II) was determined using a measuring cell (Metrohm, 6.0917.080, Switzerland) connected to a 914 pH/Conductometer (2.914.0020, Metrohm, Switzerland).

3.7.2. CHEMICAL OXIDATION DEMAND (COD)

COD (Experiments I and IV) was determined using a test kit (1.14541.0001, Merck Chemicals GmbH, Germany), before which urine was diluted with Mili-Q water depending on the concentration factor.

3.7.3. FOURIER-TRANSFORMED INFRARED SPECTRA (FT-IR)

Fourier-transformed infrared spectra (FT-IR) (Experiments I, III and IV) were recorded on a Nicolet FT-IR Impact 410 spectrometer (Madison, USA) in absorbance mode. The detector covered the range from 400 to 4000 cm^{-1} with a spectral resolution of 8 cm^{-1}. The polymer films were milled and made into small pellets with potassium bromide (KBr) using a laboratory KBr FT-IR Hydraulic Press. FT-IR spectra were used to evaluate the formation of new chemical bonds during the dehydration of the polymer films.

3.7.4. POWDER X-RAY DIFFRACTION (PXRD)

Powder X-ray diffraction (PXRD) (Experiment II) analysis was performed at 25 °C using a SPECTRUM 100 spectrometer (Perkin Elmer, USA) over the range $2\Theta = 10°\text{-}70°$. PXRD curves relayed information about the change in crystallinity of the degrading polymers.

3.7.5. GEL PERMEATION CHROMATOGRAPHY (GPC)

For gel permeation chromatography (GPC) (Experiments I-II), polymer films were prepared by grinding them to a fine powder using a mortar and pestle. Then 0.1 mg of the powder was dispersed in 1 mL tetrahydrofuran and ultra-sonicated for 15 min, after which 50 µL of the solution was injected into the GPC setup (HPLC PUMP-515; Waters Corporation, USA) with a run time of 15 min per cycle. The results were analysed using EMPOWER-2 software (Waters Corporation, USA). Changes in number average (Mn), weight average (M_w), peak (M_p), Z (M_z) and Z+1 (M_{z+1}) molecular weight of the polymers were determined by gel permeation chromatography. Some films were not soluble in tetrahydrofuran and GPC data for those films could not be obtained.

3.7.6. SCANNING ELECTRON MICROSCOPY (SEM) AND ENERGY DISPERSIVE X RAY SPECTROSCOPY (EDX)

Scanning electron microscopy (SEM) (Experiments I-II) images and energy-dispersive X-ray (EDX) (Experiment II) spectrograms were obtained using a JSM 6390LV (JEOL, Japan). An area of 4000 μm^2 was selected in the SEM images, with 2000x magnification.

SEM images gave detailed information about the changes in surface morphologies while EDX identified the presence of new elements in the degrading polymer films.

3.7.7. INDUCTIVELY COUPLED PLASMA-OPTICAL EMISSION SPECTROMETRY (ICP-OES)

The concentration of calcium (Ca) and sodium (Na) (Experiment II) in urine was measured by inductively coupled plasma optical emission spectroscopy (ICP-OES), using an ICP Avio 200 (Thermo Fisher Scientific, USA).

3.7.8. THERMAL MONITORING OF WEIGHT LOSS

A simple thermogravimetric analysis (Experiment I) was conducted by monitoring the weight loss of virgin polymers and solid residues collected after destructive sampling at different temperatures (100-550 °C) using a furnace (C290, Nabertherm GmbH, Germany).

3.7.9. POTASSIUM CONCENTRATION TEST

K concentration of urine (Experiment III) was determined using Gallery Discrete Analyzer (Catalog number: 98611001, Thermo Fisher Scientific, USA) using Potassium reagent (Ref. 984307, Thermo Fisher Scientific, Finland). The interaction between potassium ions and tetraphenylborate (TPB) results in the formation of a stable precipitate, creating a homogeneous suspension influenced by pH conditions and the inclusion of stabilizers. The measurement of this suspension is performed at 540 nm, and the rise in absorbance is directly correlated with the concentration of potassium present in the sample.

3.7.10. QUANTIFICATION OF ORGANIC METABOLITES

A targeted quantitative metabolomics approach (Experiment IV) was used that involved a combination of direct-injection mass spectrometry and reverse-phase LC-MS/MS custom assay to determine endogenous metabolites (Vergara et al., 2023) in urine,

extracted water and extracted water treated with activated carbon. The custom assay was combined with an ABSciex 5500 QTrap® mass spectrometer for targeted screening, identification, and absolute quantification of 255 organic metabolites, including amino acids, phospholipids, biogenic amines, organic acids, acylcarnitines, sphingomyelins, and nucleotides/ nucleosides. The method involved derivatization and extraction of analytes with selective mass-spectrometric detection using multiple reaction monitoring pairs. The custom assay consisted of a 96 deep-well plate with a filter plate attached with sealing tape, along with reagents and solvents used to prepare the plate assay. The first 14 wells were reserved for one blank, three zero samples, seven standards, and three quality control samples. For all metabolites except organic acids, samples were thawed on ice, vortexed, and centrifuged at 13000× G. Then, portions of the sample were loaded onto the center of the filter on the upper 96-well plate and dried in a stream of nitrogen, followed by the addition of phenyl-isothiocyanate for derivatization. Following incubation, the filter spots were dried using an evaporator, and metabolites were extracted by adding 300 µL of extraction solvent. The extracts were then transferred to a 96-deep well plate via centrifugation, followed by a dilution step with MS running solvent. For analysis of organic acids, 10 µL aliquots of the sample were loaded into the center of wells in a 96-deep well plate, followed by the addition of 3-nitrophenylhydrazine derivatization reagent and internal standard solution. After incubation for 2 hours, BHT stabilizer and water were added before LC-MS injection. The mass spectrometric analysis was conducted on an ABSciex 5500 Qtrap® tandem mass spectrometer (Applied Biosystems/MDS Analytical Technologies, Foster City, USA) equipped with an Agilent 1290 series UHPLC system (Agilent Technologies, Palo Alto, USA). The samples were delivered to the mass spectrometer using an LC method followed by a direct injection method. Data analysis was performed using the software Analyst 1.6.3 (Sciex, USA).

3.8.CALCULATIONS

Percentage swelling, a measure of water intake by a polymer relative to its initial weight (Schott, 1992), was calculated as:

$$\boldsymbol{Swelling}\ (\%) = \frac{\boldsymbol{W_s - W_i}}{\boldsymbol{W_i}} \times \mathbf{100} \tag{1}$$

where W_i and W_s are initial weight and swelled-up weight of the polymer film, respectively.

Percentage weight loss of a polymer due to degradation relative to its initial weight (La Mantia et al., 2020), was calculated as:

$$\boldsymbol{Weight\ Loss}\ (\%) = \frac{\boldsymbol{W_i - W_f}}{\boldsymbol{W_i}} \times \mathbf{100} \tag{2}$$

where W_i and W_f are initial weight and final weight of the polymer film after drying at 40 °C, respectively.

Poly dispersity Index (PDI), the ratio of weight-average molecular weight (M_w) to number-average molecular weight (M_n) of a polymer (Kissin, 1995), was calculated as (Viéville et al., 2011):

$$\boldsymbol{PDI} = \frac{\boldsymbol{M_w}}{\boldsymbol{M_n}} \tag{3}$$

where M_n is calculated based on the mole fraction distribution of different-sized molecules in a polymer and M_w is calculated based on the weight fraction distribution of different-sized molecules in a polymer.

Degradation (%) of the polymer films was calculated based on the change in molecular weight in relation to the molecular weight of the virgin polymer (La Mantia et al., 2020):

$$\boldsymbol{Degradation}\ (\%) = \frac{\boldsymbol{M_i - M_f}}{\boldsymbol{M_i}} \times \mathbf{100} \tag{4}$$

where M_i is molecular weight of the virgin polymer and M_f is molecular weight of the polymer after storage in alkalised urine.

Degree of crystallinity (X_c %) is the ratio of the crystalline fraction of a polymer to its amorphous fraction, where the higher the degree of crystallinity, the more organised the polymeric chains). X_c was calculated as (B. Aziz et al., 2020):

$$\boldsymbol{X_c = \frac{A_c}{A_t} \times 100} \quad (5)$$

where A_c is area under peaks in an XRD curve and A_t is total area under the XRD curve.

Poly dispersity index (*PDI*) is the ratio of weight-average molecular weight to number-average molecular weight of a polymer, where a PDI value of 1 indicates that the weight average molecular weight is similar to the number-average molecular weight of a polymer (Kissin, 1995). PDI was calculated as (Viéville et al., 2011):

$$\boldsymbol{PDI = \frac{M_w}{M_n}} \quad (6)$$

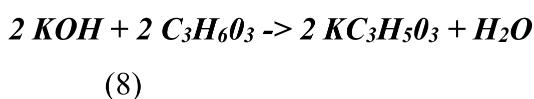
where M_w is weight-average molecular weight and M_n is number-average molecular weight.

Number-average molecular weight (M_n) is calculated from the mole fraction distribution of different-sized molecules in a sample, weight-average molecular weight (M_w) is calculated from the weight fraction distribution of different-sized molecules and peak molecular weight (M_p) is the molecular weight at the peak of the molecular weight distribution curve of the polymer. Based on molecular weights (number-average, weight-average and peak) of the biopolymer obtained by GPC, percentage degradation of the PLLA films was calculated as:

$$\%\boldsymbol{D = \frac{M_i - M_f}{M_i} \times 100} \quad (7)$$

where M_i is initial molecular weight and M_f is final molecular weight of the degraded film.

The reaction between Potassium Hydroxide and Lactic Acid is as follows (Tam et al., 1998):



$$\boldsymbol{2\ KOH + 2\ C_3H_6O_3 \rightarrow 2\ KC_3H_5O_3 + H_2O} \quad (8)$$

Where KOH is Potassium Hydroxide (56 g/mol), $C_3H_6O_3$ is Lactic Acid (90 g/mol) and $KC_3H_5O_6$ is Potassium Lactate (128 g/mol). In the rest of the article, Lactic Acid will be termed LA and Potassium Lactate will be termed KLa.

We added 0.2 g KOH in 100 mL urine.

From Eq. 1, we know that 2 moles of KOH reacts with 2 moles of LA to give 2 moles of KLa and 1 mole of H_2O.

$$\textit{Molarity} = \frac{moles\ of\ KOH}{Vol.of\ water} = \frac{0.2/56}{0.1} = 0.04\ mol/L \quad (9)$$

Therefore, the mass of KLa

= **Moles of KLa (which is equal to the number of moles of KOH) × Molar mass of KLa**

= 0.04 × 128 = 5.1g or 5100 mg (this is the maximum amount of KLa that can be formed).

$$\textit{For every 1 mole of KLa, } \left(\frac{K}{KLa}\right) = \frac{40}{128} = 0.3 \quad (10)$$

Therefore, to calculate the amount KLa formed, from Eq.3

$$[KLa] = \left(\frac{Conc.\ of\ K\ [dosed-treated]}{0.3}\right) \quad (11)$$

Where, *conc. of K (dosed*) is the concentration of K in urine after 0.2 g of KOH is mixed in urine and *conc. of K (treated)* is the reduced concentration of K in urine due to the formation of KLa.

The following equation was used to calculate the drying rate of a dehydration system,

$$\textit{Drying rate} = \{(\frac{Wu}{T})/A_p\} \quad (12)$$

Where W_u is the weight of urine dehydrated (kg), T is the time taken (day) and A_p is the area of the SAP used (m^2).

The following equation was used to calculate the moisture absorption rate of a dehydration system,

Moisture absorption rate = $\{(\frac{Wm}{T})/A_p\}$

(13)

Where W_m is the weight of moisture absorbed (kg), T is the time taken (day) and A_p is the area of the SAP used (m^2).

The following equation was used to calculate the moisture absorption (%),

Moisture absorption (%) = $(\frac{Wu}{Wm}) \times 100$

(14)

Where W_u is the weight of urine dehydrated (g) and W_m is the weight of moisture absorbed (g).

The following equation was used to calculate the water extraction (%),

Water extraction (%) = $(\frac{Ww}{Wm}) \times 100$

(15)

Where W_w is the weight of water extracted (g) and W_m is the weight of moisture absorbed (g).

The following equation was used to calculate the removal (%)of the OMs,

OM removal (%) = $(\frac{\Sigma Cu - \Sigma Cw}{\Sigma Cu}) \times 100$

(16)

Where ΣC_u is the total concentration of OM detected in urine and ΣC_w is the total concentration of the OM detected in extracted/treated water.

The following formulas are used to calculate the heat loss:

$$Q = Q_{conduction} + Q_{convection}$$

(17)

$$Q_{conduction} = \frac{k \times A \times (Tin - Tout) \times t}{d}$$

(18)

$$Q_{convection} = h \times A \times (Tpump - Tout) \times t$$

(19)

Where Q is the rate of heat transfer, k is the thermal conductivity of the glass, h is the specific convection coefficient of urine, T_{in} is the temperature inside the drying chamber, T_{out} temperature outside the drying chamber, T_{pump} temperature of the pump, h is the height of the drying chamber, A is the curved surface area of the drying chamber and t is the thickness of the walls of the drying chamber.

3.9.STATISTICAL ANALYSES

To ascertain notable discrepancies among various alkaline substrates and the products obtained in terms of nutrient recovery, physicochemical properties, and elemental composition, a one-way analysis of variance (ANOVA) was conducted at a 95% confidence interval. When a significant discrepancy was identified, the mean values were compared using Tukey's Honest Significant Difference test. The results from Tukey's multiple comparison tests were summarized using compact letter displays so that mean values that were not significantly different (at $\alpha=0.05$) were followed by a common superscript letter. Before conducting these analyses, the Shapiro-Wilk test for normality was applied, and the homogeneity of variance was assessed using the Brown-Forsythe-Levene test. All of these analyses were performed using R version 4.0.0 and RStudio version 1.2.5042 (Team, 2015) with the R-packages car (Fox & Weisberg, 2018) and agricolae (De Mendiburu & Yaseen, 2020).